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HUMAN BITE INFECTIONS OF THE HAND

WITH A STUDY OF THE ROUTES OF EXTENSION OF INFECTION FROM THE DORSUM OF THE HAND[1]

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WITH the exception of furuncles and carbuncles on the dorsal surface of the hand and proximal phalanges there are no infections which so commonly involve these areas as those resulting from human teeth. Blastomycosis and sporotrichosis, if they involve the hand, usually affect the dorsal surface, but they are of infrequent occurrence. Although relatively few cases of bite infection have been reported in the literature—some thirty-five cases prior to 1910 and considerably fewer since that time—the fact that fist fights and broken knuckles are of such common occurrence leads one to conclude that such injuries have not received the attention or study they deserve, particularly in view of the long continued infection and marked impairment of function that so often follow such injuries.

During the past three years we have had under our care thirteen patients suffering from human bite infections. They have presented such a typical course that it is apparent that there are several factors present in such cases which combine to produce a unique chain of symptoms.

While in the cases reported in the literature emphasis has been placed on the symbiosis of the spirillum and fusiform organisms of Vincent, no mention is made of two other important factors—the exact site at which and the depth to which the infectious agent is introduced into the tissues, and the anatomical arrangement of the joint capsules and of the fascial layers of the dorsum of the hand—the predominant factor in determining the extension of infection from the site of primary involvement.

It is our purpose in this report to discuss the three factors which we believe are responsible for the clinical and pathological picture; to describe what we think is a fairly typical clinical course, and to discuss this clinical course in some detail; to outline a method of treatment and to report thirteen personally observed instances of this condition.

RÉSUMÉ OF THE LITERATURE

Hultgen (1910) reported what he believed to be the first instance of "gangrenous perionychia" due to the symbiosis of fusiform bacillus and the spirochæta denticola. His

Fig. 8. Cross sections of hand 4. In A, in the region of the metacarpophalangeal joints considerable infiltration has occurred and the material has extended volarward along the interosseus and lumbrical muscles. Dorsally the subaponeurotic and subfascial spaces have been invaded. In B, very extensive distribution is seen both on the volar and dorsal surfaces. The mass lies on the volar surface of the adductor pollicis muscle separated from the thenar space only by the fascia overlying the muscle. C, a section taken through the bases of the metacarpals shows the mass lying in the two dorsal spaces of the hand and in the substance of the first interosseus muscle.

[1] The anatomical material used for experimental injections was given by the Department of Anatomy; and the roentgenograms of the injected hands were made by the Department of Roentgenology of Northwestern University Medical School.

Fig. 1. Anteroposterior and lateral roentgenograms of hand 1. The mass has filled the joint cavity, has broken through the joint capsule and spread proximally under the dorsal aponeurosis. The curved tract left by the needle is well shown in the lateral picture.

Fig. 2. Roentgenograms of hand 2. The mass, [illegible] jected into the third metacarpophalangeal joint, [illegible] ruptured from the joint and extended distalward in su[illegible] fascial spaces of index, middle, and ring fingers, and pro[illegible] malward over the metacarpus in the subaponeurotic spa[illegible].

patient was a girl of 7, who infected her left index finger by biting her nails. Smears from the girl's teeth showed the same organisms as were found in the infected finger.

Peters (1911) reported two cases of hand infection due to injuries from human teeth. In each instance the patient had struck another person on the mouth and suffered a wound from the opponent's teeth. He noted the intense swelling and œdema, and the foul discharge which followed these injuries, and in a patient who refused operation noted the development of the purplish, ragged, irregular granulations. In one case smears yielded the bacillus fusiformis and streptococcus. In the other the typical fusiform-spirillum combination was obtained.

Hennessy, Madras, and Fletcher (1920) studied carefully an instance of mouth bite infection and noted the mild systemic reaction associated with it. In this case the organisms of Vincent's angina were also found.

Pilot and Meyer (1925) at the Cook County Hospital, Chicago, treated a negress who was bitten on the left middle finger. A deep ulcer developed at the site of injury. The surface was moist, dark and green, with necrotic bone in the center. The margins were irregula[illegible], shaggy and bleeding, and a putrid purulen[illegible] discharge was present. There was modera[illegible] fever. A roentgenogram of the finger reveale[illegible] a ragged periosteum and a solution of co[illegible]tinuity of the bone resembling a fractur[illegible]. Smears from the wound yielded fusiform bacilli, spirilla, and a mixture of streptococci and diphtheroid organisms. The finger was amputated through the middle phalanx and neo-arsphenamin administered intravenously. The tissue removed showed deep infiltration with plasma cells, lymphocytes, and many eosinophils; there were few polymorphonuclear leucocytes.

Fuller and Cottrell (1927) reported a case somewhat similar to that of Pilot and Meyer.

H. R. Owen (1928) reported the case of a police officer who developed a chancre of the hand following a bite by a prisoner. Owen remarked that while this was an uncommon complication of such injuries it had occurred in the experience of many surgeons.

John B. Flick reported a case of "gangrenous infection of the hand following human bite" before the Philadelphia Academy of Surgery in 1929. The patient, a negro, [illegible] years of age, was bitten on the right thumb some five days previous to admission to the

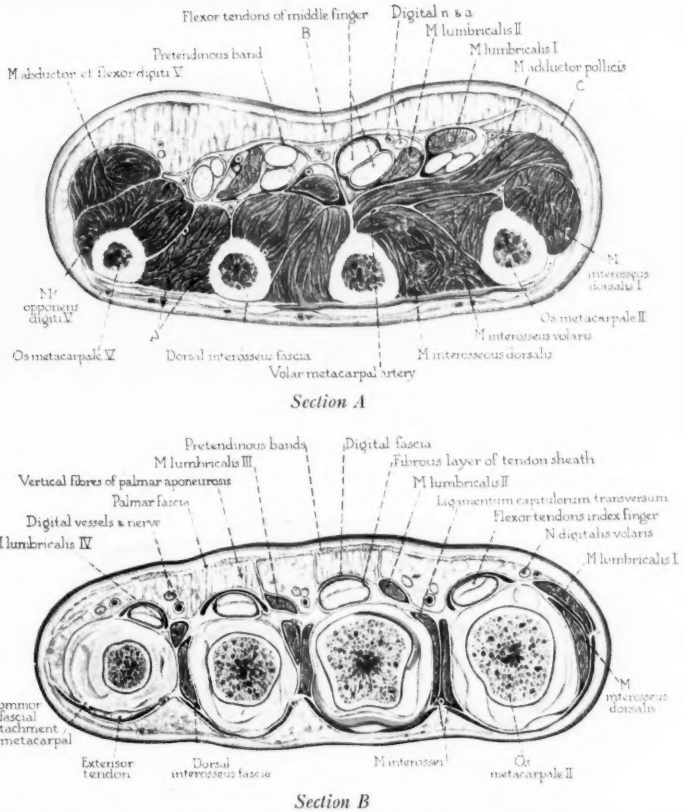
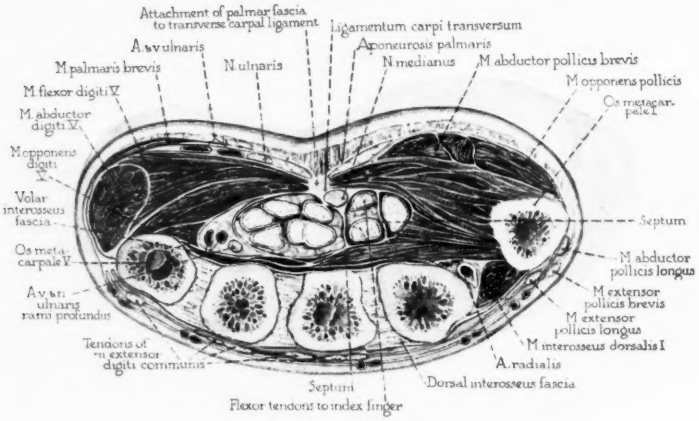


Fig. 3. Cross sections of hand 1. In section A, taken about midway between the heads and bases of the metacarpals, the injection mass lies entirely under the dorsal aponeurosis and has partially infiltrated the interosseus muscles. In section B, which passes through the metacarpophalangeal joints, the mass lies in the joint cavity and under the extensor tendon, and has been directed volarward by the lateral attachments of the latter.

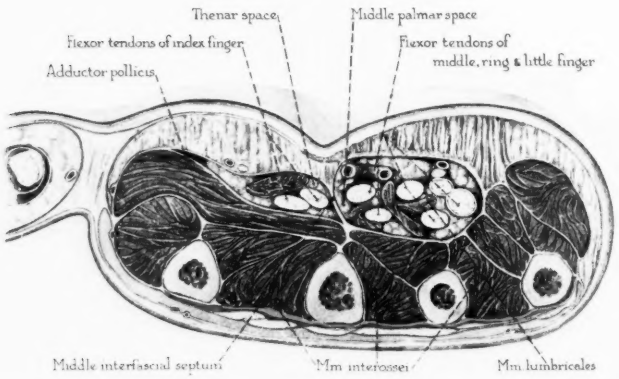
hospital. The man was toxic, had a temperature of 102 degrees F. and the forearm was markedly swollen. Upon incision of the forearm malodorous pus was evacuated, the odor being suggestive of spirochætal gangrene of the lung. The tissues were gray and œdematous. Despite wide incision the gangrenous process failed to subside and there developed extensive involvement of the hand and forearm associated with chills, fever, and jaundice. Blood culture was negative. Amputation was advised, but declined and the patient died from the infection 16 days after receiving the injury. Smears taken from the pus showed spirochætæ and numerous other bacteria, but no fusiform bacilli. The photograph of the forearm and hand which accompanied Flick's article resembles very much the hand and forearm of Case 9.

MODE OF ENTRANCE OF THE INFECTION

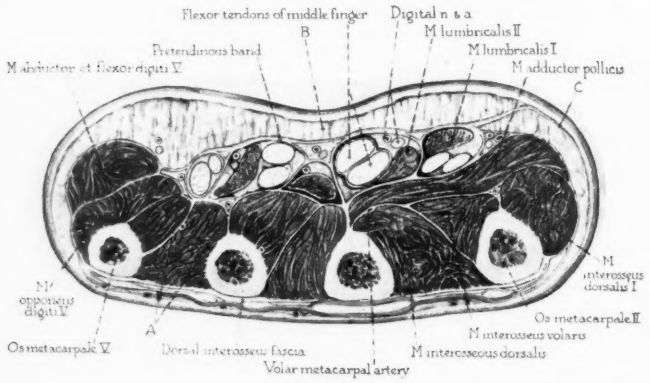
The manner in which the wound has been received plays a very definite rôle in the subsequent extension throughout the tissues of the hand. Most frequently the tooth penetrates the skin directly over a metacarpophalangeal joint, usually of the index or middle finger of the right hand. The hand doubled



Section A

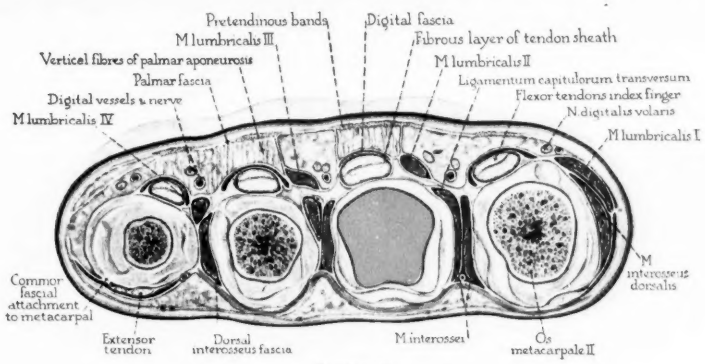


Section B

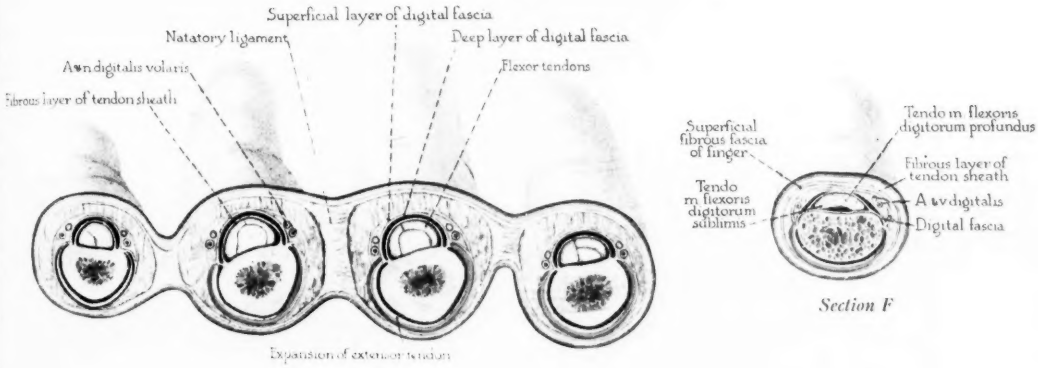


Section C

FIG. 4 (Legend on next page.)



Section D


Superficial layer of digital fascia
Natatory ligament
Deep layer of digital fascia
A. & v. digitalis volaris
Flexor tendons
Fibrous layer of tendon sheath
Tendo m. flexoris digitorum profundus
Superficial fibrous fascia of finger
Fibrous layer of tendon sheath
Tendo m. flexoris digitorum sublimis
A. & v. digitalis
Digital fascia
Expansion of extensor tendon

Section E *Section F*

Fig. 4. Cross sections of hand 2. Section A through the bases of the metacarpals shows the mass entirely under the aponeurosis, but confined to the region over the third and fourth metacarpals. Section B, taken just proximal to the midline between the heads and bases of the metacarpals, shows the material spread widely under the aponeurosis. In section C, slightly distal to the preceding one, some of the barium is seen to lie superficial to the dorsal tendon. In the region of the metacarpophalangeal joints the barium lies within the joint space and has spread distalward over the superficial surface of the extensor tendon in the dorsal subfascial space. From this region it has spread distalward, still in the subfascial space, into the fingers. (Sections E, F).

into a fist, with the skin and extensor tendons stretched tightly across the joint, comes into contact with the tooth, which usually penetrates the joint cavity. Due to the flexed position of the fingers the infectious agent is introduced at a point proximal to the attachment of the tendon to the joint capsule. When the finger is extended the original line of entrance is sealed off by the skin and tendon as they glide proximalward. This mechanism is illustrated in the lateral roentgenogram of experimental hand 1 (Fig. 1). The infectious agent is at once introduced into three spaces—the joint space, the dorsal subcutaneous space, and the dorsal subaponeurotic or subtendinous space between the tendon and the capsule, where a subtendinous bursa is usually found. At times the tooth injury is received over the proximal phalanx of the finger, in which case infectious organisms may be deposited both superficial to and under the expansion of the extensor tendon on the finger. Less frequently (Case 7) the injury involves the space on the dorsum between the heads of two metacarpals. In such a case the infectious process develops in a loose areolar space in potential communication with any of the other fascial spaces of the hand. With actual

Fig. 5. Roentgenogram of hand 3. The material injected into the third metacarpophalangeal joint has slightly invaded the subtendinous bursa.

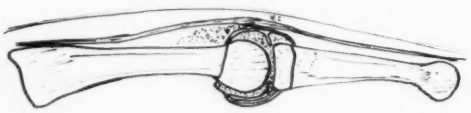


Fig. 6. A longitudinal section through hand 3 shows that the metacarpophalangeal joint is filled with the barium mass, which has broken through the capsule dorsally and infiltrated the region of the subtendinous bursa.

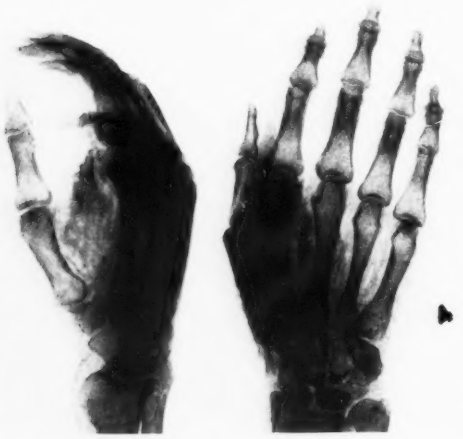


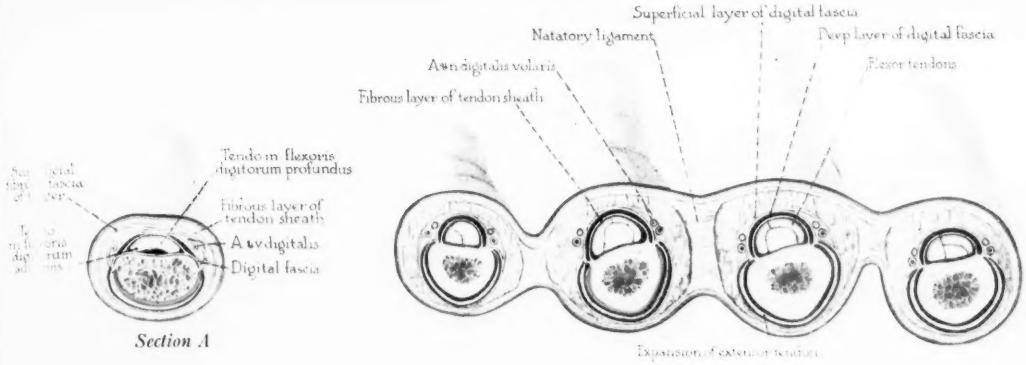
Fig. 7. Roentgenogram of hand 4. The barium mixture was injected into the metacarpophalangeal joint of the index finger and the needle then thrust farther volarward. There has been a tremendous infiltration of all the tissues.

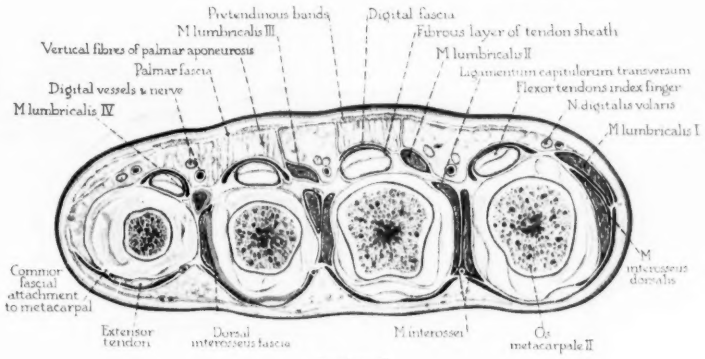
Fig. 9. Roentgenogram of hand 5. The barium was injected into the subaponeurotic space on the proximal phalanx of the ring finger and has extended both proximalward and distalward.

bite wounds the infection may enter at any location (Cases 7, 9, and 11).

After gaining entrance into the subcutaneous tissues, extension of the infection is determined by the anatomical arrangement of the tissues. The spread, however, is not entirely determined by the continuity of one fascial space with another, but also by the involvement in the process of thin fascial sheets, which when infected lead to extension throughout the spaces of which they form the covering.

Dissections of the hand, with especial attention to the region of the metacarpophalangeal joints, show that at this region there is a convergence of vessels, tendons, and fascia which come from both the volar and dorsal surfaces. The anatomy of the joint capsule itself is also of importance.





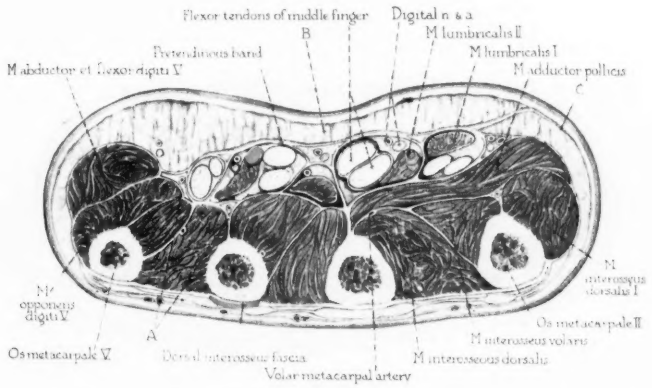


Fig. 10. Cross sections of hand 5. (The actual cross sections were made of the ulnar half of the hand only.) In A, the barium-gelatin mixture occupies the subaponeurotic space of the finger. B shows the same distribution, but brings out more clearly the relation of the material to the tendon sheath. In C, some of the mass has followed the lumbrical tendons volarward and proximalward, and in D, a small amount of injected material is seen to lie in the palm in the sheath of the lumbrical muscle.

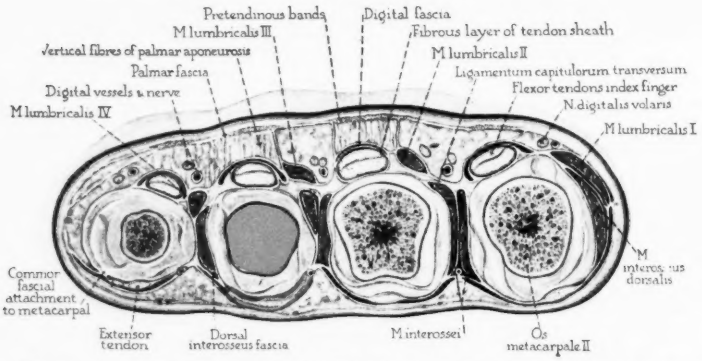


Fig. 11. Cross section of hand 6 through the region of the metacarpophalangeal joint. The fourth metacarpophalangeal joint is filled with the mixture, which also lies in the bursa under the tendon as well as dorsal to the tendon, because of leakage about the needle tract.

ANATOMY OF THE FASCIA ABOUT THE METACARPOPHALANGEAL JOINTS

The arrangement of the fascia about the metacarpophalangeal joints is rather complex since most of the layers of the fascia of the hand have some attachment at this location. Under the skin of the dorsum of the hand there is loose, areolar, subcutaneous tissue which separates it from the dorsal subcutane-

Fig. 12. Roentgenograms of hand 6. In the anteroposterior view the material is seen to overshadow the fourth metacarpophalangeal joint and the head of the fourth metacarpal bone. In the lateral view the mass fills the subtendinous bursa.

Fig. 13. Roentgenogram of hand 7. The mass appea partially to encircle the proximal phalanx and spreads o slightly proximalward. The joint is free, while on t finger soft tissues appear to be interposed between a deep accumulation of barium lying close to the bone and a mo superficial accumulation.

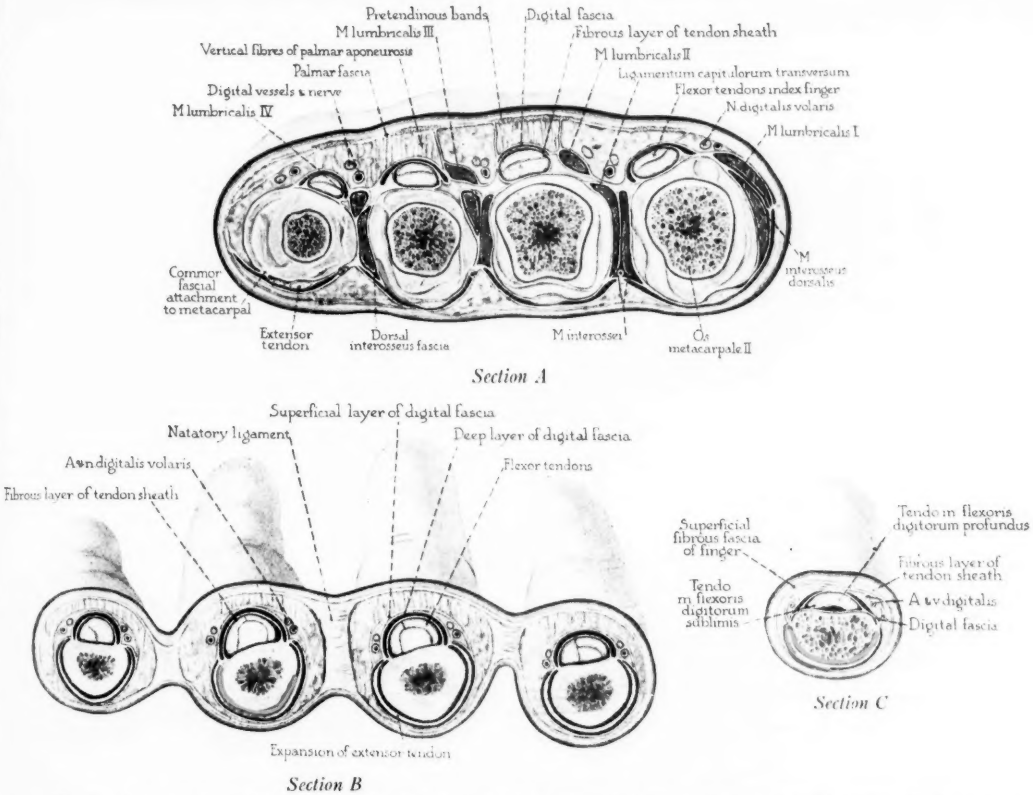
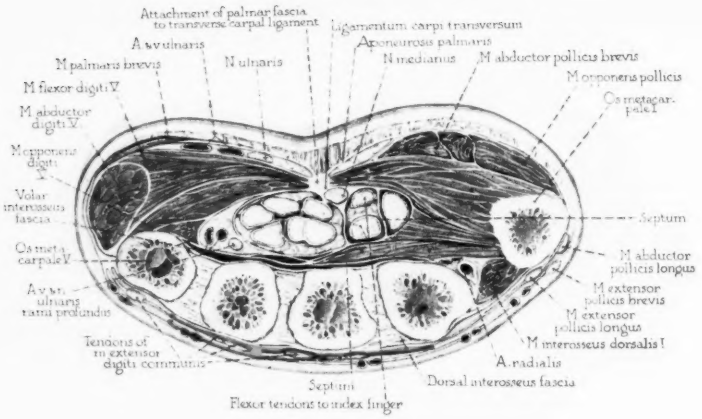


Fig. 14. Cross sections of hand 7. A, Section through the region of the metacarpophalangeal joints. B, Section through the bases of the proximal phalanges. C, Section through the distal one-half of the proximal phalanx.

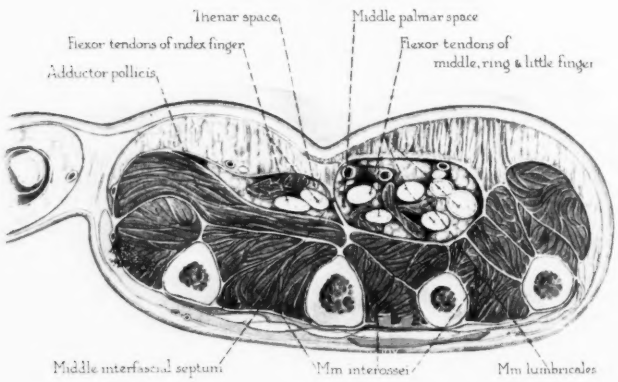
ous fascia. The dorsal subcutaneous fascia covers the back of the hand and has very loose attachments to the underlying dorsal tendons, but it is attached to the skin so that the two structures, skin and fascia, move together. This fascial layer passes distally over the metacarpophalangeal joints on to the fingers, where it becomes continuous with the superficial layer of the digital fascia. At the clefts between the fingers the fascia dips volarward to become continuous with the superficial layer of the palmar fascia, which itself is continuous with the distal portion of the palmar aponeurosis.

There is a second layer of fascia over the fingers, the deep digital fascia, which is attached laterally to the sides of the phalanges. On the volar surface this fascia splits into two layers on either side to enclose the digital vessels and nerves. Dorsally this layer forms a covering for the extensor tendon, and appears to end in the region of the metacarpophalangeal joints by becoming attached to the superficial dorsal fascia. In the region of the digital clefts the deep digital fascia becomes attached to the dorsal interosseous fascia and to the sheets of fascia which pass between the interosseus muscles.

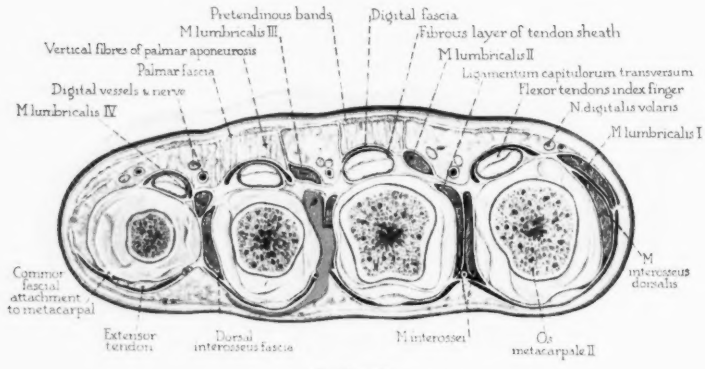
There are certain differences between the three fascial spaces which are found upon the dorsum of the fingers. The superficial fibrous fascia of the finger is closely connected to the skin by short perpendicular trabeculæ which make a fairly dense area in which the spread of infection is limited. The superficial digital and deep digital fascia are also bound to each



Section A



Section B



Section C

FIG. 15. (Legend on next page.)

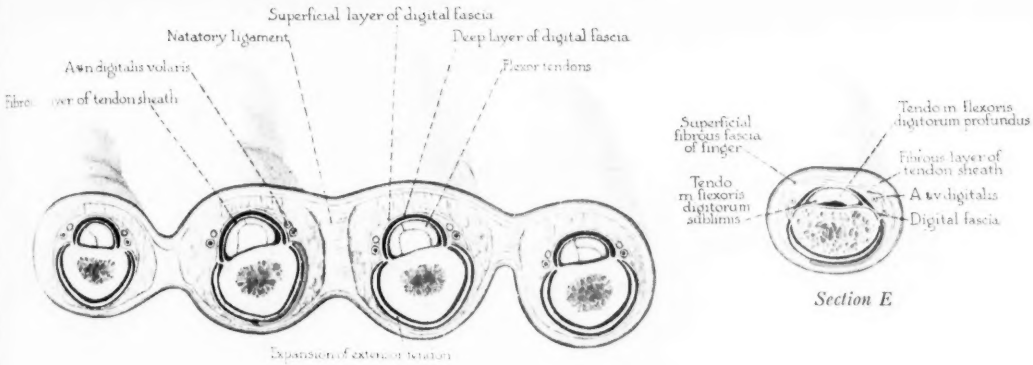


Fig. 15. Cross sections of hand 8. A, Section near the bases of the metacarpals. B, Section through the middle of the metacarpus. C, Section through the metacarpophalangeal joints. D, Section through the bases of the proximal phalanges. E, Section through the middle of the proximal phalanx of the ring finger.

other, though somewhat less securely, so that spread of infectious material between them is somewhat limited. Between the deep digital fascia and the tendon, however, is very loose areolar tissue which allows freedom of movement of the tendon. Infection in this space spreads much more easily than in the more superficial space and the infectious material is directed by the fascia around the phalanx toward the volar surface, where it comes to lie against the neurovascular tunnel leading into the palm. The extensor tendon over the proximal phalanx receives the attachments of the lumbrical and interosseus muscles.

Fig. 16. Roentgenogram of hand 8. The mass was injected into the cleft between the middle and ring fingers and has spread both proximalward and distalward.

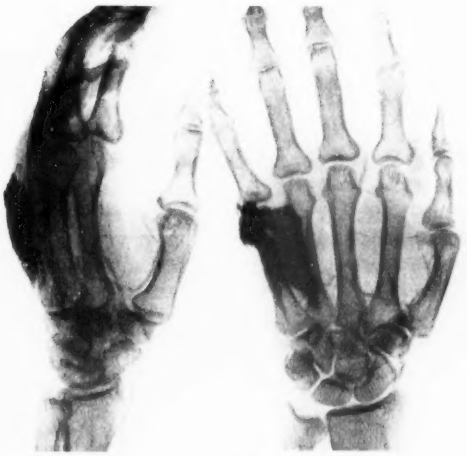
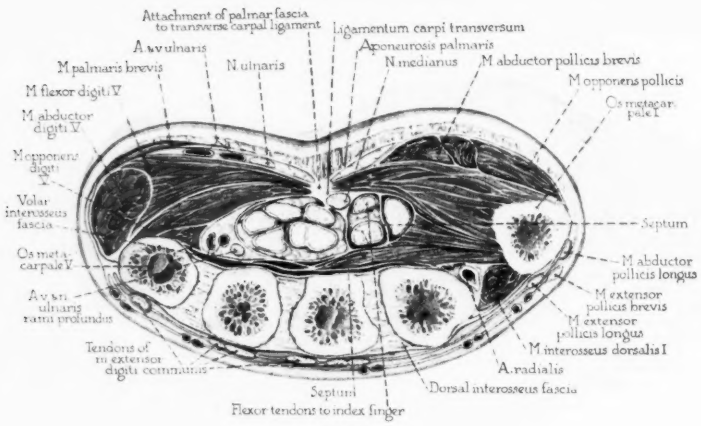
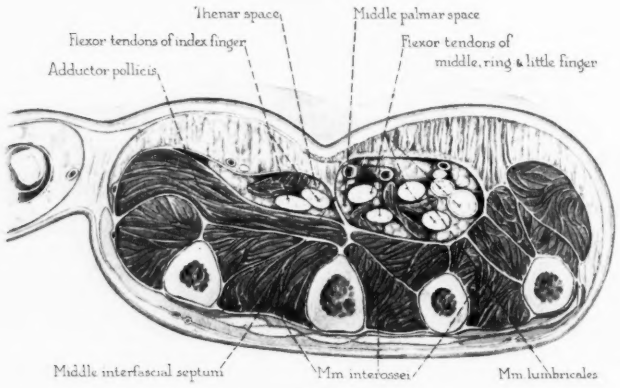


Fig. 17. Roentgenogram of hand 9. The mass was injected under the extensor aponeurosis over the fifth metacarpophalangeal joint. A considerable amount was injected, but none has spread radial to the midline of the fourth metacarpal bone.



Section A



Section B

FIG. 18. (Legend on next page.)

Consequently infection in the space between the deep digital fascia and the tendon may follow one of two possible routes to the palm: one along the lumbrical tendons, and the other in the interosseous spaces of the palm along the interosseus muscles. There is still another deeper space on the dorsum of the fingers between the extensor tendon and the periosteum over the phalanges. Infection in this space is also carried volarward around the phalanx, is in close relation to the lumbrical-interosseus tendons and lies directly over the bone, which frequently becomes involved by direct extension of the infection.

The attachment of the extensor tendon to the proximal phalanx of the finger is deserving of special mention. The tendon is securely attached to the capsule of the joint over the base of the first phalanx, so that its insertion is broken down with some difficulty. By this insertion the space under the dorsal tendon over the region of the joint is divided into two compartments, a distal and a proximal. The distal compartment lies on the proximal phalanx and is separated from the proximal compartment by the dense attachment of the tendon to the joint capsule. From the subtendinous space over the middle phalanx the distal compartment is separated by the attachment of the tendon to the base of the middle phalanx and the proximal interphalangeal joint capsule. The proximal compartment lies

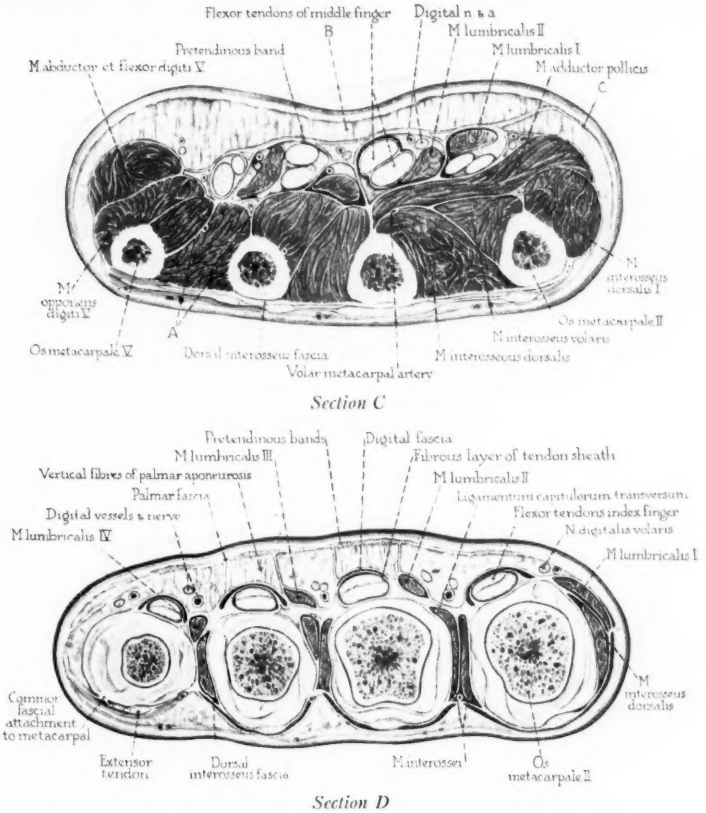


Fig. 18. Cross sections of hand 9. A, Section through the bases of the metacarpals. B, Section just proximal to the middle of the metacarpus. C, Section just distal to the middle of the metacarpus. D, Section through the metacarpophalangeal joints.

proximal to the capsular attachment of the extensor tendon and usually contains a subtendinous bursa which permits easy motion of the tendon over the head of the metacarpal bone. This bursa overlies the dorsal part of the joint capsule which in this location is quite thin.

The attachment of the tendon to the metacarpophalangeal joint is of more than theoretical interest. When the joint is flexed, as the fist is closed, the attachment is carried distally so that the knuckles are covered by the extensor tendon and subtendinous bursa proximal to the joint attachment of the tendon. Anything introduced into the subtendinous space while the hand is made into a fist must enter the proximal compartment of the dorsal subtendinous space. This space is of considerable extent and extends proximally over the metacarpus.

The attachments of the capsule of the metacarpophalangeal joints are fairly well known, but their importance in the extension of purulent exudate from the joint into the surrounding structures has not been emphasized. The capsule of the joint is lined by an inner synovial layer of fine and thin texture. Surrounding this layer is a thicker sheet of fibrous tissue which is condensed into various thickened portions so as to strengthen the joint. On the anterior or volar surface of the joint there is a dense, tough fibrous plate almost as hard as cartilage, in which masses of cartilage may at times be found.

This plate is further thickened by the addition of fibers from the fibrous sheaths of the flexor tendons. Laterally there are developed in the fibrous capsule on either side thick bands, the collateral ligaments, which run from the nodules on the dorsal surface of the heads of each metacarpal bone, distally and volarward to become attached to the lateral surfaces of the condyles of the base of the first phalanx. A less definite ligament, the volar accessory ligament, runs from the dorsal part of the capsule to the thick volar plate. There are four definite weak spots in the joint capsule, which make for greater mobility of the joint. All of them are in relation to the metacarpal attachments of the joint capsule. One lies on the volar surface at the proximal border of the dense volar plate which is securely attached to the proximal phalanx, but attached to the metacarpal bone by only a thin, redundant synovial sheet. When the joint is extended, and when the joint cavity is distended the loose attachment of the capsule becomes apparent as a thin membrane covering over the condyles of the metacarpal bone. There are two other weak spots in the joint capsule between the contiguous borders of the collateral ligaments and the accessory ligaments. A fourth and very important one lies under the extensor tendon directly over the head of the metacarpal and between the points of attachment of the collateral ligaments. It may communicate directly with the thin walled bursa which lies under the extensor tendon just proximal to the head of the metacarpal bone.

The relations of the joint to the surrounding structures are as follows: Dorsally lies the extensor tendon, which at this place is considerably thicker than anywhere else in its course, and is separated from the capsule by the subtendinous bursa. The capsule proper on the dorsum of the joint consists only of a thin synovial membrane, and the fibers of insertion of the extensor tendon. Between the surface of the cartilage covered head of the metacarpal bone and the skin are the following structures: (1) The synovial capsule, (2) the posterior or proximal subtendinous space with the subtendinous bursa, (3) the attachment of the tendon into the joint capsule, (4) the distal compartment of the subaponeurotic or subtendinous space, (5) the extensor tendon, (6) the dorsal subfascial space, (7) the dorsal fascia, (8) the subcutaneous tissues, (9) the skin.

Lateral to the joint the dorsal fascia dips down into the spaces between the heads of the metacarpal bones and becomes attached to the dorsal interosseous fascia. Between the heads of the bones over the lateral aspect of the joints, the dorsal fascia is quite thin. Under it lies the dorsal aponeurosis which is the expansion of the extensor tendons. At this point it is receiving the attachments of the interosseus muscles, and this tendinous sheet lies directly over the joint and covers over the weak spot in the lateral capsule of the joint between the collateral and volar accessory ligaments. Between the dorsal aponeurosis and the joint capsule there is a thin layer of fibrous tissue. The line of attachment of the extensor tendon to the capsule turns volarward over the lateral side of the joint and is reflected proximally so that the thinner portion of the capsule between the two lateral ligaments lies in the distal subtendinous compartment.

The volar portion of the joint capsule is the dense plate mentioned above. To its sides are attached the transverse metacarpal ligaments which hold the adjacent metacarpal heads together. Volar to the transverse metacarpal ligaments run the lumbrical tendons to the fingers. On the volar surfaces of the dense volar plate of the joint capsule lie the flexor tendons in their fibrous and synovial sheaths. The volar plate is continued proximally over the head of the metacarpal bone and becomes continuous with the volar interosseous fascia over the bone and interosseus muscles. It is not firmly attached to the head of the metacarpal bone, though a thin sheet of tissue passes from its under surface to the metacarpal. This sheet is lined on its joint surface by synovial membrane and allows free movement of the joints.

In order to test experimentally the significance of the anatomical relationships about the metacarpophalangeal joints a series of injections were made of cadaver hands after the manner of the classical experimen

undertaken by Kanavel to determine the routes of extension of infection from the subcutaneous tissues, the flexor tendon sheaths, and the various fascial spaces of the hand. Barium sulphate was thoroughly dissolved in a warm, fairly thick solution of gelatin in water. While still warm and very fluid this mass was injected under pressure into the regions most often the site of human bite injury. Most of the injections were made, therefore, into the metacarpophalangeal joints; one was made over the dorsum of the proximal phalanx and one in the cleft between two fingers. After the hands were injected roentgenograms were made and the hands were then frozen and sectioned transversely or longitudinally. These sections were carefully studied to determine the exact location of the barium mixture.

INJECTION EXPERIMENTS

Hand 1. Left hand. The needle was pushed through the skin and under the extensor tendon over the region of the third metacarpophalangeal joint. The fluid was injected under considerable pressure. The injection mass could be seen to distend the tissues of the dorsum over the joint and proximalward for some distance over the hand.

Anteroposterior and lateral roentgenograms (Fig. 1) show the joint space obscured by the shadow of the gelatin-barium mixture which has spread proximally over the metacarpal head and shaft and diffused somewhat in the contiguous interosseous spaces. The mass appears to be most dense over the head of the metacarpal bone, in the position occupied by the subtendinous bursa. The lateral roentgenogram shows the curved tract left by the solution along the course taken by the injecting needle. Details of the injection in the lateral picture are obscured by the overlying bone shadows, but it appears that the mass is densest just proximal to the joint space, i.e., in the region of the subtendinous bursa.

Cross sections (Fig. 3) show that the injection material has not extended distally beyond the joint capsule. It has, however, ruptured proximally so that it lies over the dorsum of the third metacarpal bone and the interosseous spaces between the second and third, and third and fourth metacarpals. In a section made through the hand about midway between the heads and bases of the metacarpals (Fig. 3A) the mass lies under the dorsal tendons and aponeurosis. It has infiltrated the dorsal interosseous fascia to some extent and at one point between the third and fourth metacarpals it has entered the substance of the dorsal interosseus muscle.

A section through the metacarpophalangeal articulations (Fig. 3B) shows the gelatin mixture in the joint space and under the extensor tendon. It has been directed by the lateral attachments of the tendon around the lateral surface of the joint capsule. It has pushed volarward for some distance, more on the radial than on the ulnar side and lies in very close apposition to the thin fascia covering the interosseus muscles.

Hand 2. Left hand. The needle was pushed into the tissues over the dorsum of the third or middle metacarpophalangeal joint into the joint cavity and pulled back slightly so as to lie in the cavity but not between the bones.

The anteroposterior roentgenogram (Fig. 2) reveals a tremendous spread of the injection mass. The spaces of the third and fourth metacarpophalangeal joints are obscured over their entire extent, while that of the index finger is obscured over its ulnar half. The mass has extended distally along both sides of the middle and ring fingers and on the ulnar side of the index finger half or more the length of the proximal phalanx. The spaces between the heads of the four medial metacarpals are blurred by the barium which has extended proximally over the dorsum to about the middle of the metacarpus, where it is especially marked over the second and third interosseous spaces.

Cross sections made of the hand show a rather curious distribution of the barium-gelatin mixture. In Figure 4 the sections are arranged in order, the most proximal above. In the section (Fig. 4A) taken just distal to the base of the metacarpus the mass lies beneath the extensor aponeurosis, between it and the metacarpal bones and dorsal interosseous fascia. A section (Fig. 4B) taken slightly farther distalward shows the mass still underneath the tendons and spread out over very nearly the entire dorsum of the metacarpus. It is held on the ulnar side by the attachment of the dorsal aponeurosis to the side of the fifth metacarpal. On the radial side it is held by a loose fascial attachment of the aponeurosis to the second metacarpal. In a section passing close to the heads of the metacarpals (Fig. 4C) the injection mass is seen to lie not only dorsal to the extensor aponeurosis, but volar to it as well. It lies volar to it, however, only over the third metacarpal where it has filled the joint capsule and the subtendinous bursa. To reach the dorsal surface of the aponeurosis from its point of injection into the joint cavity, the material apparently has passed through the attachments of the capsule to the under surface of the extensor tendon. It is possible to trace direct continuity of the barium-gelatin mixture from its position under the tendon to the web of the fingers where it lies superficial to the aponeurosis.

From the point of its rupture through the joint capsule it has passed distalward as well as proximalward. Distally it can be traced over the index, middle, and ring fingers (Fig. 4E) where it lies between the dorsal tendons and a thin fascial sheet which represents the dorsal portion of the deep digital fascia. Here it lies in a crescentic space, the apices of which pass to either side of the phalanx and

lie in close juxtaposition to the nerve and vascular tunnels of the volar surface. They are separated from these tunnels by a very thin fascial sheet. It is to be noted, however, that they are separated from the flexor tendons by the double layer of fascia enclosing the nerves and vessels and by the dense fibrous sheath of the flexor tendons.

Hand 3. Right hand. The needle was pushed into the third metacarpophalangeal joint space and the injection made. The needle was then pulled out slightly so that although it lay in the joint cavity it was not between the bones. The roentgenogram (Fig. 5) of this hand shows that the material is massed about the point of injection, filling the joint space and the subtendinous bursa and present in small amount in the second and third interosseous spaces.

In a longitudinal section of the hand through the midline of the middle finger and third metacarpal bone (Fig. 6), the injection mass within the metacarpophalangeal joint is seen to have gained the volar space of the joint cavity where it lies against the tough volar plate which completes the joint capsule here. Dorsally the injection mass has ruptured through the joint and has spread through the subtendinous bursa and proximalward for a slight distance under the tendon.

Hand 4. Right hand. The needle was thrust into the second metacarpophalangeal joint and the injection was made with considerable force. The needle was then pushed slightly radialward and volarward and further injection was made. The mass ballooned out the thenar space and dorsum of the hand.

The roentgenograms (Fig. 7) show a haziness over the whole radial one-half of the metacarpus. Over the middle of the metacarpus some of the material has reached the fourth metacarpal bone and is seen to extend proximally over the wrist. The first interosseous space is obscured, but it is not possible to say from the roentgenogram alone whether the thenar space is involved.

Cross sections of the hand reveal a remarkable infiltration of the tissues. On transverse section through the metacarpophalangeal joints (Fig. 8A frontispiece) the second joint is filled with the barium mixture, but the capsule has not ruptured. The material which lies outside the joint cavity presumably reached that position when the needle was pushed through the capsule, though it is not improbable that some may have been forced from the joint cavity and into the subtendinous bursa. The mass external to the joint cavity lies underneath and above the extensor tendon of the index finger and about and in the fibers of the first dorsal interosseus and first lumbrical muscles.

A section taken somewhat proximal to the preceding one (Fig. 8B), so that it passes through the thenar space, shows the mass to be widely distributed on both the volar and dorsal surfaces of the hand. On the dorsum the gelatin has spread ulnarward under the tendons to the middle of the space between the fourth and fifth metacarpals and has infiltrated slightly the second dorsal interosseus muscle. Dorsal to the extensor expansion it has spread as far as the fourth metacarpal. The subfascial mass is not so thick as the subtendinous mass. Along the radial border of the hand the material appears to have been guided by the fascia covering the first dorsal interosseus muscle. It has passed between the fascia and the muscle and spread into the space between the latter muscle and the adductor pollicis as far as the first volar interosseus muscle. It has also followed the radial border of the adductor pollicis and lies between this muscle and its fascia. It has reached the volar surface of the adductor pollicis and passed ulnarward over the volar surface of this muscle in the floor of the thenar space.

Farther proximalward less and less of the mass lies on the volar surface. The first dorsal interosseus muscle is permeated with the mixture and there is gelatin between it and the adductor pollicis, and still some in the floor of the thenar space. On the dorsum, however, the infiltration becomes more marked as the bases of the metacarpals are approached. The greater part of the injection material lies deep to the dorsal aponeurosis and has spread to the ulnar side of the hand. It has spread just as widely, but not in such great amount, on the dorsal surface of the tendons.

A section (Fig. 8C) taken through the bases of the metacarpals shows the extent of the material superficial and deep to the dorsal aponeurosis. It also shows the infiltration of the first dorsal interosseus muscle.

More proximally (not illustrated) the mass is seen to be confined more and more to the radial side of the wrist. Very little of it lies superficial to the tendons. As the region of insertion of the extensors carpi radialis appears in the sections the tendons lie deep to the injection mass which now entirely embeds the tendon of the extensor pollicis longus. A section taken still farther proximalward over the region of the dorsal tunnels shows the injection material lying just under the deep fascia along the radial side of the wrist between the extensor carpi radialis longus and brevis and the extensor communis tendons. Because of the attachments of the deep fascia at the wrist none of the mass has gone further proximalward than the radial styloid.

Hand 5. Left hand. The injection was made under the tendon on the dorsum of the proximal phalanx of the ring finger about 1.5 centimeters distal to the metacarpophalangeal joint. The needle was pointed proximalward and the solution was seen first to fill up the tissues over the proximal phalanx, and then to pass proximalward over the metacarpophalangeal joint.

The roentgenogram (Fig. 9) shows that the routine arterial injection made in preparing the cadaver for dissection overshadows somewhat the results of the barium-gelatin mass injection. The mass is seen to cover the proximal five-sixths of the proximal phalanx, the metacarpophalangeal joint, and the head

of the fourth metacarpal bone. Between the ring and little fingers the mass is seen to extend almost to the proximal phalanx of the fifth finger; it does not reach the fifth metacarpal. On the radial side of the fourth metacarpophalangeal joint the mass does not extend quite to the borders of the joint.

The specimen was divided into two parts by a longitudinal section through the midline of the ring finger and its metacarpal. The ulnar half was further divided into cross sections.

The radial half. The injection mass is seen to diffuse very slightly just under the skin at the point of injection. The main body of the material lies under the extensor tendon of the finger. Distally it extends almost to the head of the first phalanx; proximally it extends to the attachment of the extensor tendon to the joint capsule, which it has infiltrated, and lies within the loose tissues between the head of the metacarpal and the tendon.

The cross sections of the ulnar half (Fig. 10) show a much more extensive distribution of the injection mass. In the fingers (Fig. 10A) the mass extends under the extensor tendon from side to side to the points at which the tendon is loosely attached by fascia to the sides of the phalanx. It is interesting to note how well the flexor tendons in their synovial sheath are protected from the injection material. At the base of the finger (Fig. 10B) the same distribution is noted. At this point the extensor expansion is made up of the central slip which comes from the extensor communis and the lateral slips which come from the lumbricals and interossei.

A section taken through the metacarpophalangeal joints (Fig. 10C) shows that a small part of the mass has passed from the dorsum and now lies on the volar surface in the fascial coverings of the fourth lumbrical muscle volar to the transverse metacarpal ligament. On the dorsum the barium-gelatin mixture lies under the extensor tendon and interosseus muscle. The volar mass is still prevented from getting into the flexor tendon sheath by the digital fascia and the fibrous tendon sheath. It would extend more easily into the palm than into the tendon sheath. Still farther proximalward (Fig. 10D) a very small mass of barium lies under the fascia covering the fourth lumbrical muscle, while on the dorsum the mass lies under the extensor tendon confined by loose fascial attachments directly over the fourth metacarpal bone.

Hand 6. Right hand. The injection was made into the "knuckle" of the flexed ring finger; the needle was pushed proximally into the joint cavity through the tendon and then pulled back about 1 millimeter.

On roentgenologic examination of the hand (Fig. 12) the mass is seen to be confined to the region of the metacarpophalangeal joint where it overshadows the joint space. In the lateral exposure it is seen to have filled the tissue under the tendon and the subtendinous bursa.

On cross section (Fig. 11) the mass is seen to be confined to the region of the metacarpophalangeal joint. A section through the joint shows the cavity filled with barium-gelatin mixture and the loose tissues under the tendon also permeated by the mass. There has been no lateral spread. Some of the mass, as shown in the roentgenogram, also lies above the tendon, evidently the result of leakage from about the needle tract.

Hand 7. Right hand. In this hand the needle was pushed through the tendon on the dorsum of the proximal phalanx of the middle finger about 1.5 centimeters distal to the metacarpophalangeal joint and slightly to the radial side of the phalanx.

In the roentgenogram (Fig. 13) the mass appears partially to encircle the ulnar half of the phalanx. There seem to be two separate spaces in which the mass lies, one close to the bone, the other overlying the deeper compartment. It appears to be separated from the latter by soft tissues, which in the sections proved to be the extensor tendon. Although some of the injected material overlies the joint space none actually enters it.

On cross section examination these facts are confirmed (Fig. 14). In the region of the joint (Fig. 14A) some of the mass lies between the tendon and the base of the proximal phalanx on the ulnar side, but none is in the joint. Presumably the attachment of the tendon to the capsule prevents further spread proximalward. In a more distal section, through the base of the proximal phalanx (Fig. 14B), the mass lies entirely under the extensor tendon. More distally, however, over the middle of the phalanx (Fig. 14C) some of the injection material has spread about the ulnar side of the tendon and dorsally for a short distance superficial to the extensor tendon, where it lies between the tendon and the deep digital fascia.

Hand 8. Left hand.[1] The injection in this hand was made into the cleft between the middle and ring fingers on the dorsum, on a level with the heads of the metacarpal bones.

When viewed in the roentgenogram (Fig. 16) it is evident that the greater part of the injected material lies to the ulnar side of the midline between the ring and middle fingers and their metacarpals. Some of it, however, has spread beyond this line radialward and lies over the third metacarpal. Although the joint space cannot be easily visualized, stereoscopic plates show that the cavity is not filled with the barium mixture. Along the base of the ring finger the mass extends distally about one-fourth the length of the phalanx from which it is separated by soft tissues.

Sections made of this hand close to the bases of the metacarpals (Fig. 15A) show that the mass has spread widely both deep and superficial to the extensor tendons, somewhat more widely under than above them. Nearer the heads of the bones (Fig. 15B) the spread has been less extensive. Most of the material lies between the aponeurosis and the

[1] The sites of injection in hands 8 and 9 and the results obtained are very similar to those described by Kanavel in *Infections of the Hand*, pp. 138-140.

fascia, where it covers the space between the third and fourth metacarpals and overlies the fourth metacarpal as well. A smaller amount of the mass lies under the aponeurosis directly on the dorsal interosseous fascia between the third and fourth metacarpals; it has penetrated this fascia to some extent.

In the region of the metacarpophalangeal joints (Fig. 15C) the material has spread volarward, pushing aside and infiltrating the interosseus muscles and reaching the transverse metacarpal ligament. A section through the bases of the proximal phalanges (Fig. 15D) shows that the barium has spread distally under the deep layer of digital fascia. It has not penetrated to the volar surface of the finger. A section taken more distally on the ring finger (Fig. 15E) shows the material between the extensor tendon and the deep digital fascia, but none on the volar surface.

Hand 9. Left hand.[1] In this hand the needle was pushed through the tendon on the dorsum just over the head of the fifth metacarpal. Apparently the joint space was not entered.

The roentgenogram of the injected hand (Fig. 17) shows a very definite localization of the mass to the ulnar side of the midline of the fourth metacarpal bone. Although the ulnar half of the fifth metacarpophalangeal joint is obscured by the barium, the cavity does not appear to be filled with the material. The lateral view of this hand shows the great amount of material injected and speaks for the definiteness of the fascial attachments of the tendons which prevent further radial spread.

Sections made of this hand show that the barium-gelatin mixture has spread proximally almost to the carpometacarpal joints. In the most proximal section (Fig. 18A), the mass overlies and to some extent underlies the extensor tendons over the third and fourth metacarpals. Curiously it appears to be limited by the delicate attachments of the dorsal aponeurosis to the subcutaneous fascia. There is seen in this section a ring-like infiltration about the tendon of the extensor digiti quinti proprius.

A section taken about 1.5 centimeters distal to the base of the metacarpals (Fig. 18B) shows a very large amount of the mass lying dorsal to the tendons and under the dorsal fascia. Some of the mass lies under the aponeurosis over the space between the fourth and fifth metacarpals. The slight attachments of the tendons to the deep fascia here are evidently confining the mass to this location.

Still farther distalward (Fig. 18C) the distribution appears to be about as in the previous section. The mass extends ulnarward as far as the fascial attachments of the dorsal fascia to the fascia over the hypothenar muscles, while on the radial side it stops opposite the fourth metacarpal. There is a very slight amount of the mass under the aponeurosis over the fifth metacarpal.

[1]The sites of injection in hands 8 and 9 and the results obtained are very similar to those described by Kanavel in *Infections of the Hand*, pp. 138-140.

Over the metacarpophalangeal joint of the fifth finger (Fig. 18D) one sees injected material in the compartment formed by the attachments of the dorsal fascia to the dorsal aponeurosis.

(It must be assumed that in this experiment the needle was pulled out of its position under the tendon and came to lie over the tendon.)

From these injection experiments we believe that the course of spread of the process from tooth injuries in the region of the metacarpophalangeal joints, the proximal phalanges of the fingers, and the loose tissues in the web is by the following routes:

From the joint space it probably ruptures first proximally into the thin-walled bursa overlying the head of the metacarpal and underlying the extensor tendon (Hand 3; Figs. 5, 6). It is not confined here by the thin walls of this sac, but breaks through and gains the subaponeurotic space, through which it spreads proximally under the tendon (Hand 1; Figs. 1, 3). Its lateral extension under the tendon is hampered to some extent by the loose areolar tissues running from the under surface of the tendons to the dorsal interosseous fascia and metacarpal bones (Hand 9; Figs. 17, 18). Following this subtendinous pathway it may extend proximally as far as the wrist joint and laterally over a considerable extent of the dorsum. As the pus ruptures from the subtendinous bursa it comes to lie in the loose areolar tissues in the proximal part of the web of the fingers and thence may spread laterally and distally (Hand 2; Figs. 2, 4). In this position it lies dorsal or external to the extensor tendons and as it spreads distally over the fingers it lies between the deep digital fascia and the aponeurosis. It may also spread proximalward from this position and therefore for a certain distance lie dorsal to the extensor aponeurosis over the dorsum of the hand.

As it lies in the web, it comes into close relationship with the tendons of the volar and dorsal interosseus muscles (Fig. 3), which are covered by a thin sheet of fascia; and it is reasonable to assume that extension into the interosseous spaces of the hand could take place along the tendons after invasion of the fascia.

As was emphasized above the volar attachment of the joint capsule to the proximal

phalanx is very secure and immobile, while its attachment to the head of the metacarpal bone is loose, so as to allow free movements. This thin sheet of synovial membrane and fascia would offer very little barrier to extension of purulent material from the joint into the tissue lying between the metacarpal bone and the volar interosseous fascia (Fig. 6).

When the infection lies in the finger between the extensor aponeurosis and the deep digital fascia it is in close proximity to the vessels and nerves in their fascial tunnel (Figs. 4B, E; 10A, B; 14B, C; 15D, E). Although none of the material has been forced into the fascial tunnel, its walls are so thin that it would be quickly invaded by infection. It is to be noted that the flexor tendons and their synovial sheaths are well protected by the dense fibrous tendon sheath, and one would not expect a tenosynovitis to occur except late in the course of the infection. The lumbrical tendons which extend along the side of the finger to insert into the extensor tendon also lie in close relation to any infectious material which lies under the deep digital fascia. They are covered by thin fascia which is not a very secure barrier to extension proximalward. Should the process follow along one of the lumbrical tendons it would soon reach the lumbrical canal and one of the large fascial spaces of the palm (Hand 5; Figs. 9, 10).

Injection of the gelatin-barium mixture beneath the extensor tendons resulted in one case in actual injection of a lumbrical muscle and extension within the subtance of the muscle into the palm. Clinically this is a common method of extension.

In one experiment in which the needle was forced through the lateral surface of the second metacarpophalangeal joint into the substance of the first interosseus muscle, the gelatin mass besides involving an extensive area over the dorsum, found its way palmarward and into the thenar space (Hand 4; Figs. 7, 8). This extension has been observed clinically.

CLINICAL STUDY

While it is true that no two cases are ever exactly similar in any disease, there are so many things in common in mouth bite infections that a fairly typical clinical picture can be drawn. For sake of clarity we wish to present such a picture before making a more detailed study of the variations.

The patient, a young man, presents himself to a physician with a lacerated wound on the dorsum of the hand over one of the metacarpophalangeal joints. The manner in which the wound has been received is frequently not disclosed and the possibility that the wound is due to a tooth injury therefore may not occur to the physician. After the wound is cleansed and the edges of the skin trimmed away, surgical closure is often made, and it may be thought wise to suture a divided tendon and close the joint cavity.

Twenty-four or 48 hours later the patient again presents himself complaining of severe pain in the hand. The hand is then found to be considerably swollen. A lymphangitis may be present at this time, though it is by no means constant. The constitutional symptoms are not especially marked, but there is a moderate fever and a mild leucocytosis. The sutures, if any, are removed and hot wet packs applied to the hand, forearm, and arm.

The pain subsides, but the swelling and fever persist and after several days it becomes apparent that drainage is inadequate and that lateral and proximal extension has taken place. By this time the secretion from the wound is moderately profuse and usually of a very disagreeable odor; if the true nature of the infection has not been disclosed it is now suspected. The original wound is opened more widely and found to communicate with the joint cavity. A considerable amount of grayish-brown fluid pus, exceedingly malodorous, is released. Similar pus is found in the soft tissues at either side of the affected joint and beneath the extensor tendon. Smears and cultures made from the pus show many organisms, among which may be the fusiform-spirillum combination of Vincent. Drainage of the wound leads to a fall in temperature and an immediate though temporary improvement.

Soon, however, there appears an induration in the palm, either over a lumbrical canal or over one of the larger fascial spaces, i.e., the middle palmar, or, very rarely, the thenar

space. These extensions require drainage, and at operation it is noted that with pressure on the dorsal and volar surfaces of the metacarpophalangeal joint purulent material can be expressed from the palmar incisions. At the same time or later the proximal phalanx of the affected finger also shows swelling and signs of exudate. The finger becomes swollen and indurated, painful on extension, and moderately tender. The tenderness is most marked over the sides of the finger and over the metacarpophalangeal joint. There is slight or no pain over the two distal phalanges and no local pain over the course of the tendon sheath. The sides of the finger are incised, and more of the purulent exudate is released. The fibrous tendon sheath is seen to be intact though evidently inflamed, but the impression gained is that there is no pus within the sheath and it is not opened. From now on improvement takes place. The exuberant, œdematous, weak looking granulations become more red and solid. The discharge becomes progressively less, the odor disappears and after several weeks or a month or more the wounds finally heal, leaving a stiffened finger.

At irregular intervals following closure of the wound "flare ups" occur. These consist of acute inflammatory reactions either on the dorsum of the hand under the original site of injury, or in the palm. These areas are incised and the inflammation subsides promptly under hot moist packs. Cultures from these foci may show fusiform bacilli; staphylococci and other organisms are usually present. This "lighting up" may be repeated several times before final cessation, and may occur as late as 18 months after the original injury (Case 2). In some instances bone and joint involvement may have led to amputation early in the process.

DISCUSSION OF CLINICAL COURSE

In our series of 13 cases there were 12 males and 1 female, a ratio such as we should expect from the nature of the injury. All but 2 patients were young adults, from 18 to 38 years of age; patients 9 and 10 were 51 and 54 years of age respectively. In 10 instances the right hand was affected, in 3 the left hand. In all but 3 instances the injury was due to the patient striking another individual on the mouth and traumatizing the hand against a tooth. In 2 cases the patient was actually bitten, in 1 case on the right index finger, in the other on the left thumb, in each instance by a woman. In 1 instance the patient claimed to have injured himself with a tooth brush, a story which he maintained up to 18 months after the original infection. Either the story was true or the patient realized the importance of disclosing at least the nature of the source of the infection in a non-committal manner.

Two patients directly falsified at the time first aid was rendered. In 3 cases (3, 6, and 13) the patients were cared for in a hospital and fairly large lacerated wounds were sutured. Had the patients told the truth wound suture would certainly not have been performed and a more extensive disinfection of the wound would surely have been carried out.

With such a small series of cases it is difficult to evaluate the effect of the primary treatment. In 7 instances the wound was taken care of immediately by a physician. In 3 cases the usual antiseptic treatment was applied; in 3 primary suture was performed in the belief that the wound had been received under fairly clean circumstances. In 4 instances the patients applied different antiseptics themselves and consulted physicians only after swelling and pain developed. In one case nothing was done to the wound until infection developed and a physician was at once consulted. In one case no record was made as to the first aid treatment. The case in which the infection was the mildest and the one in which amputation of the arm was finally necessary were both self treated at first.

The interval of time elapsing between the reception of the injury and the onset of symptoms due to the infection was usually short. In most cases there were pain and swelling on the day following the blow. In Case 12 considerable swelling and pain were present 3 hours following the injury. In Cases 5, 6, and 13 there was considerable pain 12 hours after injury, while in the other cases, except Case 4, the interval given is 2 or 3 days. The fourth patient treated the wound himself and worked

for 10 days with no symptoms; then, following a slight trauma, a lymphangitis developed.

Extension of infection from the primary wound. The extent and manner of spread of the infection throughout the tissues indicate an extension along the fascial planes as described above, and direct involvement of the joint. In all instances, except in Case 4, in which it seems probable that the infection did not get below the digital fascia, and in Cases 9 and 11 in which a digit was actually bitten, there was first a local though diffuse extension underneath the dorsal fascia or aponeurosis in the region involved. This extension was concentric and resulted in accumulation of purulent exudate under the tendon and in the lax tissues on one or both sides of the tendons in the space between the heads of the metacarpals. In 7 instances the infection followed fascial planes from the dorsum or ruptured through the joint into one of the fascial spaces in the palm (Cases 1, 2, 3, 5, 7, 8, and 12). In 3 instances the middle palmar space was involved (Cases 5, 7, and 12) and in 2 others (Cases 3 and 8) the thenar space.

The determination of extension by fascial planes is excellently illustrated by Case 9, in which amputation became necessary. Examination of the arm at the time of amputation showed that the exudate and gangrenous process lay between the skin and the deep fascia covering the muscles, while the muscles themselves presented a normal appearance.

When the lumbrical canal is involved the infection as a rule gains entrance either by involvement of the tissues in the web or by extending proximally along the fascia of the lumbrical muscle, and the infection may remain confined to the lumbrical canal without further volar extension.

The local spread under the extensor aponeurosis becomes manifest almost at once, and it is frequently found necessary to provide for drainage in the spaces between the heads of the metacarpals at the same time the original wound is opened for better drainage. Further spread into the palm via the lumbrical canals or about the digital vessels and nerves takes place later. In general the palmar extension is evident in from 10 to 14 days following the injury, though there is apparently no definite time limit. In Case 3 the thenar space was invaded 4 or 5 days after the original injury, while in Case 2 the palmar extension was first noted one year after the original injury. In the latter case it is to be emphasized that the recurrence of trouble was due to a slight trauma. Such a train of events would indicate that the organisms reached the palm, but remained quiescent until the slight injury to the tissues caused a lighting up of the infection.

Another method of extension, illustrated in Cases 5 and 7, is about the proximal phalanx of the involved finger. In each instance this extension was noted during the third week, i.e., after the extension into the palm. Pus in these cases was located laterally on the fingers, presumably under the deep digital fascia, and did not extend across the volar surface of the phalanx until later. Such swelling, associated with the considerable pain on motion of the finger due to joint involvement, and volar tenderness, due also to infection in the metacarpophalangeal joint may lead one to suspect invasion of the flexor tendon sheath. There is not, however, rigidity of the whole finger as in tenosynovitis; only the metacarpophalangeal joint is held flexed while the interphalangeal joints can be moved with slight pain. The tenderness is also usually confined to the sides of the proximal phalanx and the volar and dorsal surfaces of the metacarpophalangeal joint. In Case 7 the possibility of an infection of the flexor tendon sheath was considered before incision of the lateral digital extension. It was decided not to open the sheath both because of the absence of unequivocal physical findings, and because it was believed that if the sheath were already involved, the tendons could not be saved, and that if it were not involved, opening of the sheath would surely lead to infection and necrosis of the tendons. The subsequent course of events proved the wisdom of this decision, and the experimental observations described above show why the flexor tendon sheath is not commonly involved.

Bone and joint involvement. Some involvement of the bones and joints was shown to be present in 10 of the 13 cases (Figs. 19, 20, 21, 22, 23, 24, 27, 28, 29, and 34). In eight of these the metacarpophalangeal joint was involved

and roentgenologic examination showed rarefaction and some destruction of bone. The arthritis quite evident clinically in the early stages of the infection can be roentgenologically proved during the second or third week. In two instances (Cases 6 and 7), in which we had opportunity of securing several roentgenograms, the bone involvement was seen to improve with conservative treatment. The destructive process in the joint and in Case 7 the periosteal proliferation showed evidences of healing and clinically a return of motion. In only 3 instances was bone involvement sufficient to lead to operative attack on the bone. In Case 3 a very persistent discharge with a continuous moderate rise in temperature lead us to curette the joint space. This we know now was a mistake since it lead at once to a severe osteomyelitis of the proximal phalanx and metacarpal bone and healing took place only after removal of the involved parts of these bones. In another instance a bite had lead to considerable osseous destruction about the distal interphalangeal joint (Case 11, Fig. 34) and a few bits of necrotic bone were removed at the time of incision. No further operative treatment was required. In the third instance (Case 12) the head of the fourth metacarpal was found to be necrotic at the time of operation and had to be removed. Apparently the bone infection is chiefly a periostitis and unless sequestrum formation develops it is better treated conservatively. If adequately drained, the infection of the joint cavity gradually clears up and does not necessarily lead to a bony ankylosis. (See especially Cases 6 and 7; and Figs. 23, 24, 27, 28, and 29.)

Recurrences of infection. A word should be added about late manifestations of infection. These may occur during the first 2 or 3 months after injury, or, as in Case 2, may not appear for a year after the original injury. In this connection Case 4 presents particular interest. Here the wound had healed within 10 days after its reception. A slight trauma, however, was sufficient to cause the infection to flare up again. In Case 6 there were four recrudescences of the infection—3 months, 4½ months, 5½ months, and 11 months after the original injury. One of these can be definitely ascribed to the application of a splint which fit tightly over the involved joint. In Case 2 the palmar extension did not become manifest until a year after the initial infection and followed slight trauma to the palm from the handle of a barber's chair.

BACTERIOLOGICAL FINDINGS

Records of cultures or smears are found in 7 of our 13 cases. In one instance (Case 3) a pure culture of bacillus proteus vulgaris was obtained. This infection was especially destructive, lead to extensive osteomyelitis of the bones entering into the formation of the joint, and subsided only after resection of considerable portions of the bones. In Case 5 smears and a single culture showed a mixed infection with no apparent predominant type. No fusiform bacilli or spirilla were seen. Anaerobic cultures were not made and it is therefore not possible to say if bacillus fusiformis was present or not. In Case 6 three cultures were made. At first a single aerobic culture gave a pure growth of staphylococcus albus. A month later careful anaerobic cultures made by Dr. W. J. Nungester of the Department of Bacteriology, Northwestern University Medical School, failed to yield any growth. Another month later smears and anaerobic culture showed a pure growth of bacillus fusiformis (Fig. 25). In this case the infection persisted for 7 months. During the latter part of this time, at intervals of almost exactly 1 month, acute exacerbations occurred. The area of the original injury became red, swollen, and painful. On each occasion a simple stab incision released 1 or 2 cubic centimeters of pus, and hot, wet dressings for a few days resulted in complete cessation of both pain and discharge. At the last recrudescence of the process about 3 cubic centimeters of pus was released. Numerous smears made of this pus revealed no organisms.

It is interesting to speculate as to the reason for the almost clock-like regularity of the "flare ups." The causative organism grew only under strict anaerobic conditions and began to appear in the cultures only after some 6 days. It may be that the incisions changed their oxygen relations; that after closure of the wounds they began to multiply

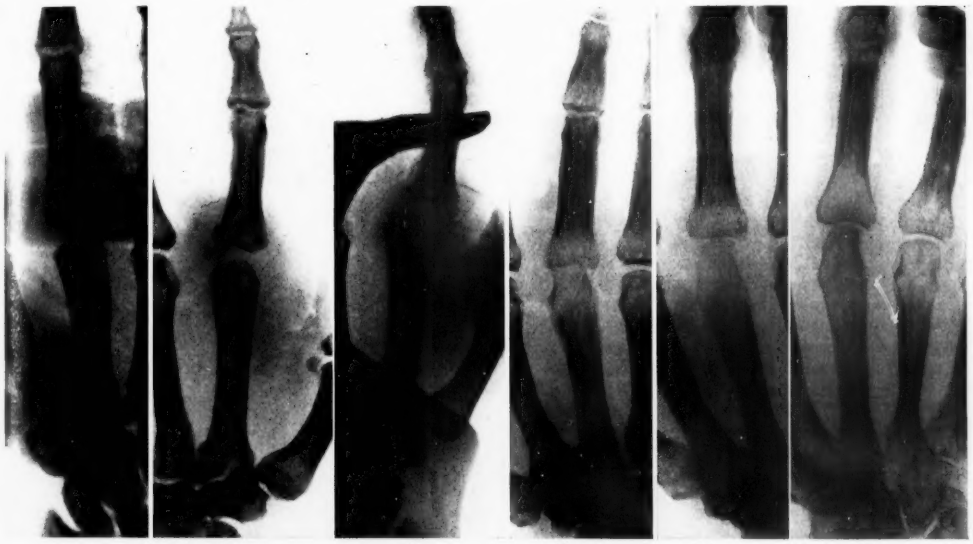


Fig. 19 Fig. 20 Fig. 21 Fig. 22 Fig. 23 Fig. 24

Fig. 19. Roentgenogram of hand, Case 1, showing periostitis of the proximal phalanx of the middle finger and decrease of joint space.

Figs. 20 and 21. Roentgenograms of hand, Case 3, showing the progressive destruction of the metacarpophalangeal joint of the index finger.

Fig. 22. Roentgenogram of the hand, Case 5, showing the obliteration of the joint space of the metacarpophalangeal joint of the middle finger.

Figs. 23 and 24. Roentgenograms of hand, Case 6, showing obliteration of the joint space of the metacarpophalangeal joint of the middle finger and atrophy of the bone. This is more marked in Figure 23. Figure 24, taken 4 months later, shows definite improvement in the process.

again and reached a sufficient growth to lead to symptoms only after 4 to 5 weeks. Possibly trauma lead to the exacerbations.

In Case 7 several smears and cultures were made. At first staphylococcus aureus and albus only were recovered. Later a mixture of staphylococcus aureus, bacillus mucosus capsulatus, and streptococcus salivarius was obtained. At another time a smear yielded various coccal forms and a culture made at the same time by Dr. A. A. Day of the Department of Bacteriology, Northwestern University Medical School, yielded a pure culture of streptococcus salivarius.

In Case 8 streptococci, staphylococci, and bacillus coli were found. This might well be expected though we have not found bacillus coli mentioned previously as a contaminate in mouth bite injuries.

Smears made from Case 11 (Fig. 33) showed the typical bacillus fusiformis-spirillum combination which is so frequently reported as having been found.

In Case 13 one set of cultures prepared anaerobically revealed no growth. A second set of cultures prepared at the time Dr. Shearon incised the finger yielded a hæmolytic streptococcus and an anaerobic gram negative bacillus, not bacillus fusiformis.

While the bacteriological study of our cases is by no means complete it represents fairly well the conditions present. The infection is not due to any one type of organism, but in every instance is a mixed infection, certainly at the onset. The fusiform spirillum combination is frequently found, and is accountable in part for the foul-smelling, gangrenous lesions so often present. These organisms are associated, however, with others found in the mouth, especially staphylococci and streptococci. In none of our cases was the spirochæta pallida implanted.

PROGNOSIS

The patients are incapacitated for a considerable period of time following the injury.

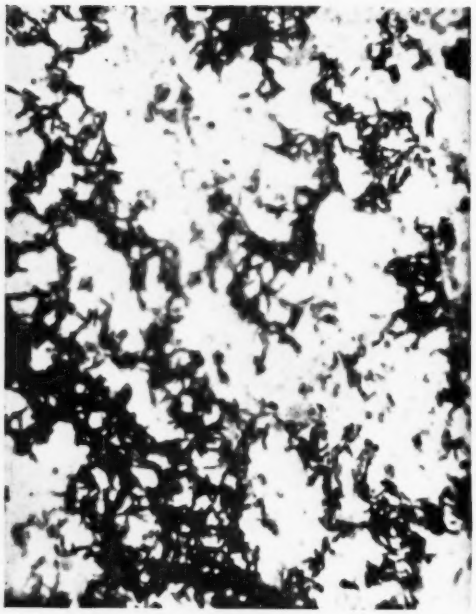


Fig. 25. Pure culture of fusiform bacillus taken from Case 6, 6 months after the initial infection.

Except in very mild infections in which the organism has not been introduced below the various fascial sheets of the hand the period of disability is reckoned in months and weeks instead of days. Patients 3, 6, and 7 were incapacitated for 3, 7, and 5 months, respectively, following the onset of the infection and even then had residual disability.

None of the patients have succumbed to the infection, though in one instance (Case 9) it was necessary to amputate the arm because of an ascending gangrenous infection which followed the fascial planes up the forearm and threatened the patient's life. In no other instance did the infection appear to be dangerous to life and in no other case was amputation of even a finger necessary to cure the infection. In Case 3 a flail finger resulted from removal of the joint, a procedure which resulted in controlling the infection, but lead to a useless digit which might have been better amputated in the first place. In the cases treated conservatively, notably Cases 6 and 7 in which the bone was not "scraped," the arthritis and periostitis gradually improved and both patients are beginning to show movement in the involved joint. While it is doubtful if complete restoration will take place still there is a fair degree of movement of the affected fingers and such a termination is preferable to amputation.

TREATMENT

The principles of treatment of bite infections are not different from those of other infected wounds, but the factors emphasized above—the complicated anatomical arrangement of the tissues of the dorsum of the hand and fingers, which predispose to the extension of infection rather than to limitation of it, the presence of a mixed infection with organisms of relatively high virulence, and the relatively low resistance of fibrous connective tissue to infectious processes in general—tend to prolong unduly the course of such infections, to predispose to the destruction of fascia and tendons and to the involvement of bones and joints, and, as a result, to produce eventually a more or less extensive impairment of function.

Although we have not had the opportunity of treating a single case primarily, or immediately after the injury, we believe, as a result of our observations, that the most important factors in the primary treatment are careful cleansing of the wound without any attempt at wound closure, hospitalization, and either the immediate application of warm, wet, sterile dressings, or institution of Carrel-Dakin treatment, with the utmost care to prevent the addition of further infection.

Cleansing of the wound, we believe, should be done gently, and with soap and water rather than with powerful chemical solutions which are quite as likely to kill living cells as to kill bacteria which have been introduced into the tissues. Obviously damaged tissue should be cut away, and the wound left widely open without any packing or gauze which might interfere with drainage. In Case 7 which was first seen by us days after the injury, the wound had been tightly packed with a gauze "drain," which acted instead as a barrier to the escape of infectious material. Its removal was followed by the discharge of a considerable amount of foul pus, which in this

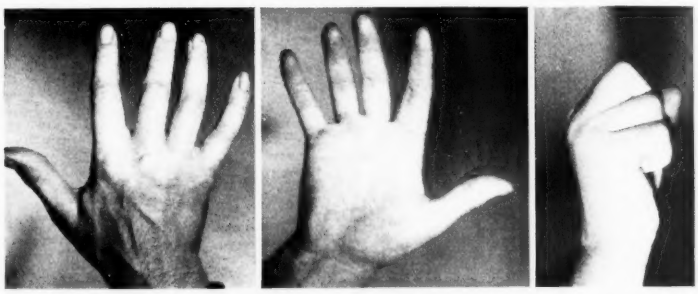


Fig. 26. Photographs of the right hand, Case 6, 8 months after the infection. The scar at the site of the injury is seen on the dorsum over the third metacarpophalangeal joint. Function of the finger has returned practically to normal.

case had acted just as the barium gelatin when injected subcutaneously under pressure.

The continuous application of warm, wet, sterile dressings produces an active hyperæmia and mobilizes the forces that overcome infection. It should not be continued, however, long enough to produce œdema of the part and maceration of the superficial tissues. Intermittent soaking in warm, sterile solution, or the use of Dakin's solution should be substituted for the continuous warm, wet dressing before the hand becomes congested—usually at the end of 3 or 4 days.

Extension of infection should be carefully watched for. The surgeon should remember that extension of infection is likely to take place (1) lateralward in the soft, superficial subcutaneous tissue of the dorsum of the hand; (2) under the digital fascia of the proximal phalanx, and so around the finger; (3) more deeply, distalward along the proximal phalanx under the extensor tendon, with subsequent periostitis and osteomyelitis; (4) on the dorsum of the hand, as distinguished from the finger, under the extensor tendons and the fibrous tissue which unites them to form the dorsal aponeurotic layer; (5) along the lumbrical canal into the palm and thence into the middle palmar or thenar space; (6) less commonly, and usually at the end of 10 or 12 days, through the joint into the palm, under the volar interosseous fascia and thence into the middle palmar or thenar space; and (7) by erosion of the fibrous flexor tendon sheath into the sheath, with involvement of the synovial sheath and flexor tendons.

Successful treatment requires the recognition of extension of infection to these different sites, and incision before the accumulation of pus under pressure causes extensive necrosis of tissue. Incisions for drainage, needless to say, must be made with due regard for important anatomical structures. If infection extends through the joint into the palm, the affected space in the palm should be drained, but through-and-through drainage of the hand, we believe, is never indicated.

"Scraping of the bone" and curettage of the joint cavity, as has been emphasized above, is likely to do more harm than good. If the infection of the soft tissues, fascial spaces, and the affected joint is adequately drained, bone involvement tends to clear up spontaneously. We have seen sequestrum formation in only one case, even though roentgenograms have shown evidence of extensive periostitis and grating sounds on movement have given definite evidence of destruction of joint cartilage. Even though joint cartilage is destroyed, bony ankylosis does not necessarily take place, and mobility may still be preserved if efforts are made to prevent fibrous ankylosis by the institution of early movement.

A word of warning may be in place with regard to the interpretation of roentgenograms in these cases. Not infrequently the surgeon or radiologist forgets how quickly atrophy of disuse makes itself apparent by the absorption of lime salts from the bones of the hand. A diagnosis of osteomyelitis and bone destruction has been made on several occasions when

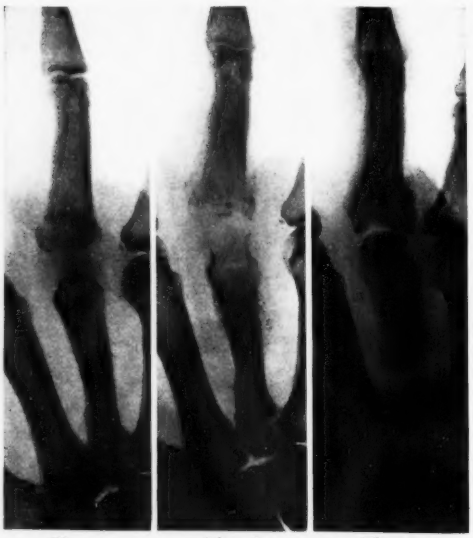


Fig. 27 Fig. 28 Fig. 29

Fig. 27. Roentgenogram of the right hand, Case 7, taken February 4, 1930. The destructive process is distinctly visible in the fourth metacarpophalangeal joint. Its further progress is seen in Figure 28, and its diminution in Figure 29.

Fig. 28. Roentgenogram of Case 7 taken February 25, 1930. Compare with Figures 27 and 29. There is considerable destruction of bone and periostitis of both the proximal phalanx and metacarpal bone of the ring finger.

Fig. 29. Roentgenogram of right hand of Case 7, taken April 12, 1930. Compare with Figures 27 and 28. Definite evidence of healing is present.

slight infection was present and the process of rarefaction was mistaken for infection.

Involvement of the flexor tendon sheath, as has been pointed out above, is unusual. It occurs as a late result of extension of the infectious process through the metacarpophalangeal joint into the palm. In one case (Case 10) this palmar extension was not recognized until erosion of the fibrous sheath and invasion of the synovial sheath had occurred. In the other case in which involvement of the flexor tendon sheath occurred (Case 12) a rubber tube had been passed from the palmar surface to the dorsum of the hand between the third and fourth metacarpal bones. Not only was the fibrous tendon sheath eroded with a resulting tendon sheath infection, but the flexor tendons of the ring finger were divided by pressure erosion of the tube combined with the destructive action of the infectious process.

Fig. 30. Photograph of the right hand, Case 7, taken 9 days after the injury. The site of the injury is indicated by the granulating wound on the dorsum between the middle and ring fingers. The incision between the ring and little fingers was made for drainage of the subaponeurotic space. The volar view shows the incision made for drainage of the lumbrical canal and the incision made for drainage of the subaponeurotic space of the ring finger. Both views show the typical swelling of the proximal phalanx.

Although we have not seen a case in which a syphilitic infection was transmitted to the injured hand, this possibility, as is emphasized by the case reported by Owen, should not be forgotten. In one case (Case 10), in which the Wassermann reaction 4 weeks after the injury was negative, neosalvarsan was given intravenously but apparently without any helpful effect.

SUMMARY

Bite infections are frequently prolonged in their course and difficult to clear up because the infection is usually introduced deeply into the tissues through a comparatively small wound, because of the character of the infection, because of the anatomical arrangement of the structures involved, and because of the relatively low resistance of fascia, tendon, and bone to a mixed infection such as is caused by the organisms present in the mouth.

Such infections when introduced into the tissues of the dorsum of the hand—the most common site of inoculation—tend to spread to definite areas, and this extension depends particularly upon the exact site and depth of the primary inoculation and upon the ease or difficulty with which the infectious material can escape to the surface.

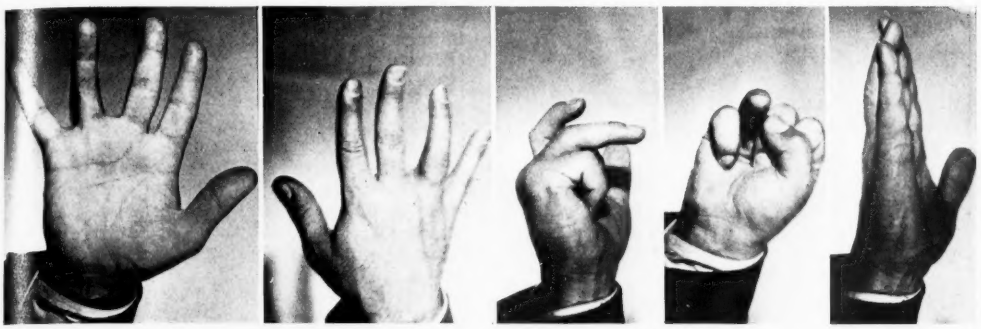


Fig. 31. Photograph of right hand, Case 7, taken May, 1930. The incisions have healed, pain has disappeared and motion is returning.

In the treatment of such infections an exact knowledge of the sites to which infection tends to spread is of importance. These are in order of frequency, the subcutaneous space of the dorsum of the hand, the subfascial space of the dorsum of the proximal phalanx, the subaponeurotic spaces of hand and fingers which lie directly over metacarpal bones and proximal phalanges, the metacarpophalangeal joint, the fascial spaces of the palm and the flexor tendon sheaths. If these sites are kept in mind, extension of infection can be recognized early and accumulations of pus drained before extensive necrosis of tissue has taken place.

Unless such infections are drained early and adequately, bone, joint, and tendon involvement are certain to occur and to lead to extensive impairment of function.

RÉSUMÉ OF HISTORIES OF THIRTEEN CASES OF PATIENTS WITH HUMAN BITE INFECTIONS

CASE 1. S. F., Wesley Memorial Hospital, 141940 (December 15, 1928–December 26, 1928). Three weeks before admission to hospital the patient struck his fist against another man's tooth with a resulting wound over the metacarpophalangeal joint of the right middle finger. During the 2 days following the injury the hand became very swollen and painful, and the patient consulted a physician who made roentgenograms and ordered a salve and hot, wet packs. A week later the dorsum of the hand was incised and hot packs were again ordered and continued for a week. A roentgenogram taken at this time showed joint involvement. The day previous to admission a small "pocket of pus" in the palm of the hand was incised.

On examination there was found a moderate swelling over the dorsum of the hand, especially over the metacarpophalangeal joint, where there was an open discharging wound in which were two gauze drains. On the palm between the metacarpal bones of the middle and ring fingers there was an inch long incision in which there was also a gauze drain. Flexion of the middle finger was found to be impaired; otherwise movements of the hand were free. A roentgenogram (Fig. 19) showed periostitis of the proximal phalanx of the middle finger with decrease in the joint space of the corresponding metacarpophalangeal joint. The drainage subsided rather promptly after removal of the drains and the application of hot, moist packs for a few days.

CASE 2. R. T., Wesley Memorial Hospital, 144030 (April 21, 1929–April 25, 1929). In November, 1927, the patient cut himself with a tooth brush across the dorsal aspect of the metacarpophalangeal joint of the right middle finger. The wound became infected and drained for about 5 weeks, but finally healed, apparently completely. In September, 1928, he accidentally bruised the palm of the hand. The injury was very painful; more so, he thought, than it should be. Considerable swelling developed and pus was thought to be present. In November, 1928, the palmar area was incised with release of pus. Drainage persisted for 3 days and subsided. Subsequently, however, the whole hand bothered him considerably. About 10 days before admission to the hospital the swelling of the hand recurred and the palm seemed to flatten out. He then consulted us and we advised hot soakings. As a result of this treatment the swelling subsided quite promptly, and there appeared a small yellow fluctuating area in the palm.

He entered the hospital, April 21, 1929. A small scar could be seen on the dorsum of the hand over the metacarpophalangeal joint of the middle finger. In the center of the palm was a fairly superficial fluctuating area, just distal to the thenar eminence and lying over the third metacarpal bone. Close to it was a healed scar from an incision made 5 months previously. A slight amount of pus was released from the fluctuant area in the palm and the process healed rapidly after the application of hot, moist dressings.

A B C

Fig. 32. Photographs of left hand, Case 9. A, Photograph taken day previous to operation. There is swelling over the dorsum of the hand and thenar space. B and C, Photographs taken 7 weeks after the injury. The wound has healed, movement is returning in the interphalangeal joints; the metacarpophalangeal joint is fixed in extension.

Case 3. V. F., Wesley Memorial Hospital, 144410 (April 20, 1929–June 8, 1929). This man was admitted to hospital April 20, 1929, with an open lacerated wound over the metacarpophalangeal joint of the left index finger. He stated that he had fallen and cut his hand on a piece of tin. The wound was carefully cleaned and sutured by the house surgeon, who told the man to return the following day for dressing. The day after the injury the dorsum of the hand was greatly swollen and painful. The patient had a temperature of 101.2 degrees and looked ill. All the stitches were removed and the man put to bed with hot, moist packs over the hand and forearm. There were painful axillary glands on the affected side and it was assumed that we were dealing with a streptococcic infection. There was as yet no odor from the wound to excite our suspicion and we did not doubt the patient's story. In a few days a swelling developed in the thenar space. The wound was explored and the thenar space incised April 27, 1929. The wound over the metacarpophalangeal joint, about 1¼ inches long, was filled with unhealthy exuberant granulations and bits of necrotic tendon could be seen in it. At the base of this wound the roughened uncovered surface of the bones entering into the formation of the metacarpophalangeal joint could be felt. There had been an extension of pus into the space between the index and middle fingers. No connection could be found between the dorsal wound and the thenar space though the joint space was not explored. The thenar space was opened along the radial border of the second metacarpal, and about one and one-half ounces of stinking yellow pus evacuated. The original wound was also enlarged and the cleft between the index and middle fingers incised. On obtaining the foul smelling pus we at once realized we were dealing with a human bite infection and the patient admitted this later.

Hot, moist dressings were reapplied and the man's temperature came down rapidly to normal. After some two weeks, however, it was apparent that drainage was not adequate. There was still very abundant malodorous drainage, and occasional rises of temperature. A roentgenogram (Fig. 20) made of the hand showed considerable erosion and destruction of the joint and head of the metacarpal. May 14, 1929, the original incisions were enlarged, the joint space curetted, and considerable necrotic bone removed. From this time on, despite heat and the use of Dakin's solution the destructive action of the infection on the bone progressed. A roentgenogram May 27, 1929 (Fig. 21), showed considerable infection of the bone and joint. The joint surfaces were practically destroyed, and there was considerable periostitis of the shafts of the bones. Culture of the wound made at this time showed a growth of bacillus proteus vulgaris (Hauser).

The best procedure at this time would undoubtedly have been amputation of the finger. The dead bone, however, was resected and the wound healed promptly, but the patient was left with a flail finger which will undoubtedly require amputation.

Case 4. F. R., Passavant Memorial Hospital, 101 (June 26, 1929–June 29, 1929). Ten days previous to entrance to the hospital the patient struck another man in the mouth and received a slight wound on the dorsum of the right hand just distal to the metacarpophalangeal joint of the index finger. He put mercurochrome on the wound and applied a dressing. Everything seemed all right until he accidentally struck the finger, at which time it swelled and became painful. On admission to the hospital there was a small open wound just distal to the joint, with very slight non-odorous purulent discharge. The dorsum of the hand was much swollen, and there was a red streak running up the forearm. No glands were palpable in the axilla. The application of hot, moist dressings resulted in prompt subsidence of pain and swelling. It was several weeks, however, before the wound finally healed.

Case 5. B. L., Passavant Memorial Hospital, 434 (September 3–October 7, 1929). Eleven days previous to admission to hospital the patient struck a man on the mouth receiving a deep gash over the third metacarpophalangeal joint of the right hand. He was seen at once by a physician who applied iodine and strapped the wound tightly with adhesive. On the next day the hand became red and swollen and he was seen by Dr. L. H. Hines who applied hot, moist packs. Pus began to drain from the wound 2 days later and he was taken to a hospital where the wound was enlarged for better drainage. After this procedure he obtained relief for several days, but subsequently the swelling and pain recurred with such severity that he was unable to sleep. At Dr. Hines' request he was then admitted on our service at Passavant Memorial Hospital.

On admission he had a ragged, discharging, foul smelling wound over the dorsum of the third metacarpophalangeal joint of the right hand. There was considerable general tenderness over the whole

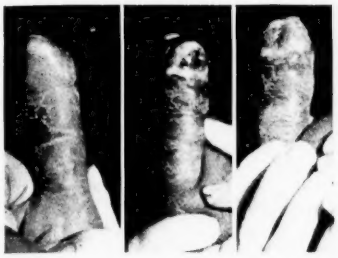


Fig. 33. Case 11, three weeks after bite injury of right index finger.

finger, not limited to the tendon sheath, and it was possible to extend the fingers without pain. The epitrochlear glands were enlarged and painful, but there were no red streaks of lymphangitis. The temperature at time of entrance was 98.4 degrees and it did not rise above 99 degrees during his 2 weeks' hospital stay. Blood examination made at the time of entrance showed a red count of 4,800,000, hæmoglobin of 80 per cent, a white count of 10,700, with 61 per cent polymorphonuclear neutrophils, 35 per cent lymphocytes, and 4 per cent transitional cells.

Hot packs were applied for 2 days with alleviation of pain and decrease in the amount of discharge, after which dressings moistened with Dakin's solution were applied for 5 days. The discharge diminished, but it was evident that drainage was not adequate; there was some tension in the palm, and it was thought wise to secure better drainage. This was done August 31, through an incision on the dorsum along the ulnar side of the third metacarpal bone. Considerable pus and granulation tissue were removed. Because of the palmar tenderness the middle palmar space was opened in the cleft between the middle and ring fingers. No pus was found, though there was considerable œdema and thin yellowish fluid. A Carrel tube was placed in the dorsal wound and the use of Dakin's solution continued. Cultures made from the pus showed a profuse growth of various organisms, a large and small coccus and a bacillary form being the most prominent. Anaerobic cultures were not made.

From this time on improvement was steady but slow. During convalescence a collection of pus found its way to the surface on the radial side of the proximal phalanx of the finger. This drained for a few days and ceased. A roentgenogram (Fig. 22) showed an obliteration of the joint space, atrophy of the bones, and slight periostitis of the metacarpal and the proximal phalanx. On one occasion, several weeks after discharge from the hospital, the region over the metacarpophalangeal joint became red and fluctuant. Simple stab incision into the center with release of a small amount of pus resulted in prompt healing.

Case 6. T. B., Northwestern University Surgical Dispensary, 22718-E. On September 6, 1929, one month previous to his admission to Northwestern

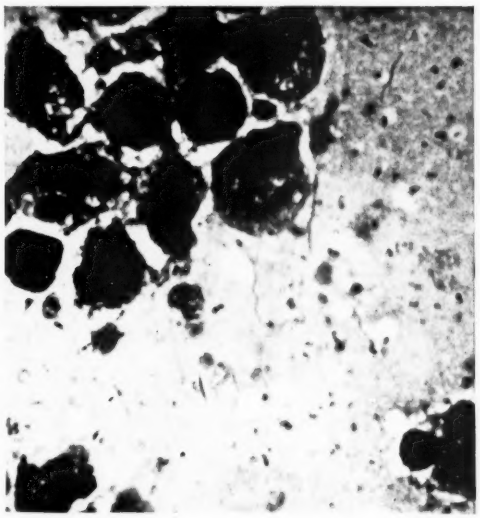


Fig. 34. Photomicrograph of the pus from Case 11. Original magnification circa 1,500. There are numerous pus cells among which are seen spirilla and fusiform organisms.

University Surgical Dispensary, the patient, a man of 24, struck a man on the mouth and received a wound over the dorsum of the metacarpophalangeal joint of the right middle finger. The wound was sutured at a hospital, where he did not reveal the true nature of his injury. The hand became very much swollen and painful. On the following day the wound was reopened, and hot, moist dressings were applied. A moderate discharge developed, which, however, cleared up in 2 or 3 weeks. He applied to the dispensary for treatment, October 9, 1929, because the hand had become very stiff from long immobilization. At this time a diagnosis of involvement of the third metacarpophalangeal joint was made and a roentgenogram made (Fig. 23). Physical therapy was instituted to mobilize the interphalangeal and metacarpophalangeal joints.

Fig. 35. Case 11. Osteomyelitis and suppurative arthritis have lead to a pathological dislocation at the distal interphalangeal joint.

We first examined the patient November 3, 1929. At this time there was a hard swelling about the third right metacarpophalangeal joint with redness and blanching on pressure. The interphalangeal and metacarpophalangeal joints of all the fingers showed definite limitation of motion presumably due to fibrous thickening of the joint capsules. The roentgenogram taken some time previously showed an arthritis with destruction of cartilage of the third metacarpophalangeal joint (Fig. 23). The roentgenologists suggested that there was probably bony ankylosis.

Physical therapy was continued, but it was advised not to massage or move the involved joint. On December 21, 1929, a swelling had developed over the dorsum of the joint, with an area of fluctuation in the center. This was incised and a moderate amount of pus was released. An aerobic culture of this pus resulted in a pure growth of staphylococcus. The inflammation responded rapidly to hot, moist dressings. Physical therapy was again instituted in January. On February 1, 1930, he returned with a second swelling in the same location as the first. This was incised and anaerobic cultures were made. The swelling receded rapidly after the application of heat. The cultures remained sterile even after a week's incubation.

Movements were gradually improving in the hand, and on February 8 a tension splint was applied to assist in obtaining extension of the fingers. A roentgenogram (Fig. 24) made at this time showed that the density of the third metacarpal had returned to normal. There was no evidence of active infection at this time. The man returned on March 1, 1930, with a third swelling of the hand in the same location as the previous two. He had worn the splint for 24 hours and believed that pressure of the dorsal plate on the injured area had caused a flare up. This area was again incised with release of pus, from which anaerobic cultures were made. Hot, wet packs were applied and in a week the inflammation was gone. The anaerobic cultures from this pus showed after 6 days a pure culture of fusiform bacilli (Fig. 25).

The man was seen again early in May, 1930. He had been back at his work as a painter for some 6 weeks, and had good use of the hand. The movements in all but the middle finger had returned to normal. In the middle finger flexion and extension of the interphalangeal joints were normal, but there was still some limitation of motion in the metacarpophalangeal joint (Fig. 26), the range of movement being from 180 degrees' extension to 135 degrees' flexion. The patient was again seen on August 2, 1930. He had had no trouble with the hand until 3 days previously, when following a hard day's work the dorsal swelling recurred with considerable throbbing pain. He applied hot, wet packs for 3 days and came to the dispensary when he believed incision was indicated. At this time the whole dorsum of the hand was red and swollen and there was a point of localized tenderness just to the ulnar side of the midline of the metacarpophalangeal joint of the middle finger. No fluctuation was present and it was not thought advisable to incise at the time. On August 4 the man was given 0.6 gram of neosalvarsan and on August 6 an incision was made and about 3 cubic centimeters of dark flocculent pus was released from beneath the extensor tendon. Smears from this pus failed to reveal any organisms.

CASE 7. F. H. T., Passavant Memorial Hospital, 1573. A policeman of 38 years, was bitten by a negro on the dorsum of the right hand in the space between the middle and ring fingers on January 2, 1930. The wound was treated at once by a physician, who applied antiseptics and packed the wound with gauze. The hand was swollen somewhat the following day, and there was slight drainage on the second day following injury. On January 15, the hand became intensely swollen and painful and he was admitted to Passavant Memorial Hospital at 9 p.m. At the time of admission there was an open draining wound on the ulnar side of the middle finger at the level of the head of the metacarpal. The epitrochlear glands were enlarged. The temperature was 101.2 degrees F.

Further drainage was instituted at once. The original wound on the dorsum was enlarged and considerable foul pus poured into it from the interdigital space between the ring and little fingers; this space was then drained directly by a longitudinal incision immediately over it. There was rather profuse hæmorrhage from several large subcutaneous veins which were divided in the incision. Massive hot, moist packs were applied. Immediately following the operation the patient suffered a chill which lasted 15 minutes. A culture taken from the pus at this time was reported to contain staphylococcus albus and aureus.

Following drainage the temperature dropped to 99.4 degrees F., the swelling decreased, and the pain practically disappeared. That the process was not brought to a standstill was shown by the fact that the malodorous drainage persisted, and by the daily rise in temperature to 101–101.4 degrees F. On January 21 swelling and tenderness on the volar surface of the hand over the metacarpophalangeal joint of the ring finger were first noted. There was considerable pain on extending the finger and a point of tenderness was present in the lumbrical space between the ring and little fingers. The question of tendon sheath involvement was considered but the localization of pain to the joint on extension of the finger pointed rather to involvement of this structure as the source of the pain.

On January 22, the lumbrical swelling was incised. Pus was found extending palmarward from the dorsal infection. The tendon sheath of the flexor tendons of the ring finger was œdematous and gray. Massive hot, moist packs were again applied.

The following day there was still considerable pain on extending the ring finger. We feared that the sheath was infected, but felt that if it were not already infected it surely would be if it were opened

and that if it were already involved the chances of saving the tendon would be slight even if the sheath were adequately drained. It was decided, therefore, not to open the sheath. The white count on January 24 was 10,100 with 74 per cent neutrophils.

The pain on extending the finger gradually diminished, but although the temperature dropped after the drainage of January 22, it again rose and on January 29, a fluctuant swelling appeared over the radial side of the proximal phalanx. The white count at this time was 14,150. The swelling was incised and grayish-green, foul smelling pus was evacuated. At the same time, the incision over the fourth lumbrical canal was lengthened and opportunity taken to examine the tendon sheath again. The outer fibrous sheath was œdematous, but it was not thought that there was pus within it. It was not opened. Forceps were passed into the incision between the third and fourth metacarpals and bare bone was felt. Smears taken from this pus showed a few fusiform organisms and an occasional spirillum.

On January 31, the white count had dropped to 11,700 and from that time on the temperature remained about normal. The hot, moist packs were continued until February 2, when they were replaced by Carrel-Dakin treatment. The swelling over the proximal phalanx receded somewhat, but failed to disappear completely. Pressure over it and over the metacarpophalangeal joint lead to exudation of yellowish-gray pus from the palmar incision. A roentgenogram on February 4 (Fig. 27) showed some destruction of the distal end of the fourth metacarpal bone as well as some damage to the fourth metacarpophalangeal joint. The white blood count was still increased slightly, to 11,900.

On February 6, a small incision was made over the palmar surface of the proximal phalanx of the ring finger and pus and necrotic tissue were evacuated. Hot, moist packs were again instituted. A smear taken from the pus at this time showed a highly motile coarse bacillus, unidentified, and culture showed staphylococcus aureus, bacillus mucosus capsulatus and streptococcus salivarius. No spiral forms were visible on dark field examination.

The day following this operation the white count was 14,200, but the temperature was not above 99.2 degrees F. and the condition gradually improved. Dr. A. A. Day of the Department of Bacteriology, Northwestern University Medical School, made another culture from the wound and secured a pure growth of streptococcus salivarius.

On February 11 the temperature reached normal. The swelling slowly decreased, but still remained most marked over the metacarpophalangeal joint and proximal phalanx of the ring finger (Fig. 30). The white count February 11 was 10,950.

By February 22, all incisions were beginning to heal; there was still some discharge, but it was much less offensive and the granulations were becoming less œdematous. The patient was discharged from hospital February 22.

On February 25, a roentgenogram (Fig. 28) revealed a definite osteomyelitis involving the distal end of the third metacarpal and the proximal end of the proximal phalanx of the ring finger.

The patient was seen daily for several weeks, and then at intervals until May 15. Discharge persisted from the dorsal incision at the original site of injury for some 2 weeks, and for almost the same time from the palm. The incisions, however, healed slowly. Some 3 weeks after discharge from hospital a small fluctuant area over the volar surface of the metacarpophalangeal joint was incised without anæsthesia. A small amount of necrotic fat was released. This incision healed almost immediately.

A roentgenogram made April 12 (Fig. 29) showed evidence of progress toward cure. There were periosteal thickenings both in the fourth metacarpal and proximal phalanx of the fourth finger and some evidence of damage in the joint as well, but in the judgment of the roentgenologist, Dr. James T. Case, the process was subsiding.

The man was last seen May 15. At that time he was developing movement of the finger (Fig. 31), and the decision with regard to incision of the tendon sheath appeared to have been vindicated.

Case 8. E. B., Cook County Hospital, 1143985 (November 30, 1929–December 14, 1929). One week previous to entrance into hospital the patient, a man of 31 years, struck another man on the mouth and split open the skin over the knuckle of the left index finger. He paid no attention to the wound until 2 days later, when because of the pain he began to soak the hand in boric acid solution. He continued this treatment for 2 days without relief, and then went to a physician who trimmed the edges of the wound, removed some black material from it, and ordered hot boric acid soakings every 2 hours. These were kept up for 3 days, but because no improvement took place his physician advised him to go to the Cook County Hospital for treatment. (We are indebted to Dr. Edward Lyon, Quincy, Illinois, at that time senior surgical interne at Cook County Hospital, Chicago, for the careful record made of this case. The patient was also presented by him at the December meeting of the Cook County Hospital Surgical Society.)

At the time of admission to the hospital the temperature was 101.6 degrees and the pulse 140. There was a sinus over the dorsum of the metacarpophalangeal joint of the left hand, from which a greenish-yellow thick, stinking pus exuded (Fig. 32). The tissues over the thenar space were tense, red and swollen; there was considerable swelling of the dorsum of the hand and impairment of flexion of the metacarpophalangeal joint of the finger. There was no lymphangitis or lymphadenopathy. Hot boric packs were ordered and a roentgen examination of the hand requested. Two days after admission it was evident that further drainage was required and on December 3, 1929, the wound on the dorsum was enlarged. Some necrotic tendon was excised and the thenar space was opened from its palmar sur-

face. Considerable pus was released from the dorsum, but none from the thenar space. The temperature just before operation had reached 103 degrees. Cultures made from the pus revealed a mixed infection of hæmolytic streptococcus, staphylococcus albus, and bacillus coli. Hot boric dressings were again applied and kept up for 2 days after which Carrel-Dakin treatment was instituted. The temperature dropped to 101 degrees the day following operation and reached 101 degrees the second day, after which it remained normal. A week following operation a small abscess or extension of the original process appeared on the finger. This was reached with a pair of forceps through the original incision and was drained.

A roentgenogram made December 16, 1929 showed an osteomyelitis of the bones forming the metacarpophalangeal joint.

The man was discharged 2 weeks after admission and reported daily for dressings. Healing took place slowly but was complete 4 weeks after his discharge from the hospital. Before healing was complete physical therapy was begun and when last seen the patient was able to extend his finger completely and to move it fairly well at the interphalangeal joints. At the metacarpophalangeal joint, however, there was almost complete fixation in extension (Fig. 32).

Case 9. G. L., Cook County Hospital, 1001536 (February 3, 1927–March 16, 1927). A laborer, aged 51 years, was bitten on the left thumb by a woman 4 days previous to his admission to the Cook County Hospital. The wound was washed in cold water and Sloan's liniment and arnica and iodine were applied. Two days later the thumb became very painful on movement and throbbing pain developed on the right side of the wrist. At the time of admission to the hospital, 4 days after the injury, there was a swelling of the thumb and wrist, more marked on the dorsal surface, and slight oozing of serous fluid from the wound edges. The axillary lymph glands were somewhat enlarged and sugar was present in the urine. The day following admission the thenar space was opened widely by an incision on the dorsum of the hand, and hot, wet dressing applied.

Following the institution of drainage the patient felt somewhat better, but the temperature remained elevated and ranged between 100 and 102.8 degrees F. Despite the continuous application of hot packs and the forced administration of fluid the pain returned in the hand and arm, the forearm and arm became red and very much swollen, and the senior interne on the service, Dr. Oscar Richter, noted crepitation extending over the forearm. The pus from the draining wound was described as having a "terrible odor."

Three days after the first operation we were asked to see the patient. At that time the tissues about the drainage incision had become black and the edges had separated widely. There was an extensive moist gangrene of the subcutaneous tissues and extensor tendons, with a profuse, fæcal-smelling, brownish-black discharge. The entire forearm was dusky, hot and tense. Several long incisions from the wrist to the elbow were made immediately, Carrel tubes were inserted and treatment with Dakin's solution was instituted.

There seemed to be some relief from the toxic symptoms as a result of the drainage, but it was only temporary. Although the temperature did not again rise over 101.2 degrees F., the patient became very toxic, and 2 days after the second operation developed a hiccough which persisted with little respite. Four days following the second operation it was obvious that the infection was still spreading upward and would soon prove fatal if not arrested. Under nitrous oxide anæsthesia the arm was rapidly amputated midway between the elbow and shoulder. Although there was a very extensive infiltration and gangrene of all the subcutaneous tissues of the forearm and lower one-half of the arm the muscles at the site of amputation were red and healthy, and apparently not involved in the infectious process.

Following the amputation the man made a slow, but steady recovery which was hampered somewhat by his diabetic condition. He was discharged March 16, forty-one days after admission, with a granulating wound over the stump of the arm.

The condition of the hand and forearm in this case very closely resembled the excellent photograph of a similar case reported by Dr. John B. Flick.

Case 10. H. W., Cook County Hospital, 1111948, 1112446, 1117638 (April 13, 1929–April 16, 1929; April 16, 1929–May 20, 1929; May 20, 1929–July 27, 1929). This man, a police officer, was admitted to the observation ward of Cook County Hospital April 13, 1929 shortly after being bitten on the dorsum of the third right metacarpophalangeal joint by a drunken patient.

He was seen at the time of entrance by Dr. Roger Vaughan who confirmed the examining room diagnosis of suppurative arthritis and ordered continuous hot boric packs applied to the hand. The temperature at this time was 100 degrees F. and the man complained of considerable pain in the hand. For the next 2 days the hot packs were kept up, but the pain was not relieved and the man was transferred to our service on April 15, 1929.

At that time there was a draining sinus on the dorsum of the right hand just radial to the middle metacarpophalangeal joint. There was also considerable swelling of the entire dorsum of the hand. The patient's temperature was 102 degrees F. Under nitrous oxide anæsthesia a vertical incision was made just radial to the extensor tendon of the middle finger. Considerable thick foul pus was released from under the tendon and dorsal aponeurosis, and oozing of pus was observed from a small opening in the joint capsule. Voluminous hot moist boric packs were applied. On the following day the temperature dropped to 100 degrees F. and at no time afterward did it rise over 101 degrees; within a week it had reached normal.

On April 17, 1929, the œdema had subsided considerably though there was considerable foul drainage and subcutaneous necrosis still present in the wound. The hot moist packs were kept up until April 19, at which time Dakin's solution was applied, at first as a continuous drop and later for saturating the dressings, which were changed twice daily. The pain in the hand subsided slowly with a tendency to occasional exacerbations, but not of the original severity. As the swelling subsided the edges of the wound became covered with large exuberant granulations from the center of which thick green pus exuded.

On May 6 marked tenderness on movements of the middle finger was still present. There was also slight tenderness on the palmar surface of the metacarpophalangeal joint. It was thought at this time that osteomyelitis was developing and that there was probably some necrosis of the extensor tendon of the middle finger. A roentgen-ray examination made May 13, revealed a destructive process of the proximal end of the first phalanx of the right middle finger and distal end of the third metacarpal. Although the patient's Wassermann reaction was negative he was given three injections of neosalvarsan by the senior interne, Dr. Philip Shapiro, with the object of combating spirillum infection (Pilot and Meyer).

On May 24, the palmar tenderness of which the patient had complained from time to time became definitely more marked and an area of palmar discoloration and swelling, concerning the presence of which there had been some doubt, became definitely apparent. Three days later under nitrous oxide anæsthesia an incision was made into the middle palmar space on a line with the cleft between the middle and ring fingers. Not only was there pus in the middle palmar space, but the infectious process had eroded the fibrous flexor tendon sheath as well and was extending distalward within the flexor sheath.

In spite of wide incision and drainage of the tendon sheath the flexor tendons subsequently became necrotic and the palmar wound continued to drain until the necrotic tendons were removed.

A roentgenogram made June 17, showed a definite osteomyelitis involving the terminal phalanx of the right middle finger and corresponding metacarpal and a destructive arthritis between the third metacarpal and the first phalanx.

On July 27, 1929, the patient's wounds were completely healed with the finger fixed by bony ankylosis at the metacarpophalangeal joint and slightly flexed at the interphalangeal joints. Movement at the latter joints was of course impossible because of the loss of the flexor tendons.

Case 11. C. C., Cook County Hospital, 1157234 (March 4, 1930–March 31, 1930). Three weeks previous to admission to the Cook County Hospital the patient, a woman of 25 years, was bitten by another woman on the right index finger. Shortly afterward the finger became swollen and painful and despite home remedies the infection became gradually worse.

On admission there was noted a marked swelling of the dorsum of the middle phalanx of the right index finger (Fig. 33). Along the lateral side of the finger were several sinuses discharging a grayish-yellow pus of extremely foul odor. The finger was only moderately tender and flexion and extension caused only moderate pain. The temperature at this time was normal and at no time during her hospital stay did it rise over 99.6 degrees F. Smears taken from the pus (Fig. 34) showed spirilla and fusiform bacilli along with numerous cocci and bacilli and many pus cells. There were seen a few round bodies with double contoured membrane and clear cytoplasm, but no mycelia or yeast forms. Peroxide dressings were applied and a roentgen examination was requested. This revealed an osteomyelitis of the distal half of the second phalanx and proximal half of the terminal phalanx (Fig. 35). The blood Wassermann was negative. A laboratory culture from the wound showed a hæmolytic staphylococcus.

Four days after entrance into hospital the finger was opened by crucial incision and material for biopsy removed. This showed a non-specific inflammation.

Eleven days following her admission to the hospital she was seen by us in consultation. Carrel-Dakin treatment and careful attention to the prevention of reinfection was advised before considering the question of amputation. Under Dr. L. Cardon's care the finger continued to improve and the patient was discharged on the twenty-seventh day with a granulating wound still present, but with the infection well under control.

Case 12. J. V., Michael Reese Hospital, 96775 (March 25, 1928–April 28, 1928). Three days before admission to hospital March 25, 1928, the patient, aged 26 years, was set upon by three men and in the ensuing fracas struck one of them in the mouth with his right fist. There was considerable bleeding from the resultant wound. Immediately after the fight the hand was washed in hot water and boric acid solution and mercurochrome applied. Three hours later when in bed the patient noticed the pillow was soaked with blood and the hand considerably swollen.

The following day he consulted a physician who washed the wound, applied mercurochrome and dressed it. In the evening he was taken to a hospital and hot, wet dressings were applied to the hand. Because he was dissatisfied with the treatment he left the hospital the following day, and went to a physician who enlarged the wound and removed a considerable amount of old blood from beneath the subcutaneous tissues of the dorsum of the hand. Before the incision was made the patient had a severe chill lasting about 5 minutes.

On the morning of admission to the Michael Reese Hospital the patient had more chills during one of which he became cyanotic.

On admission at 11 a.m., March 25 his tempera-

ture was 103.2 degrees F., his pulse 100, and respirations 20. A blood examination showed hæmoglobin of 85 per cent and a white count of 14,700. The urine examination showed a trace of albumin. The Wassermann and Kahn tests were negative. The hand was described as markedly swollen and painful.

From March 25 to April 5 active antiseptic treatment was carried out. The hand was soaked for 15 to 30 minutes once or twice daily in 1:10,000 mercuric chloride solution. Between soakings hot boric dressings were applied and irrigations with Dakin's solution or mercurochrome were carried out three or four times daily. Once each day a gutta percha drain was removed and another inserted. The patient's temperature ranged between 98 degrees and 102.4 degrees F.

April 5 a roentgenogram was made and a report of "negative for osteomyelitis" returned.

April 6 the urine showed acetone and a trace of albumin. On the same day an incision was made on the palmar surface of the hand from the middle of the palm distally to the ring finger. Necrotic tissue and loose cartilage from the head of the fourth metacarpal bone were removed and a rubber tube was inserted between the third and fourth metacarpal bones through the hand from the palm to the dorsal surface. April 10 the patient's temperature reached normal and remained normal thereafter, although the swelling, pain, and wound discharge continued without abatement. April 14 the dorsal incision was enlarged under local anæsthesia.

On April 18, when we first saw the patient, the hand was markedly swollen and painful, there was a profuse foul discharge from the palmar and dorsal incisions, and there was marked tenderness over the flexor tendon sheath of the ring finger. This finger could not be moved actively. Under nitrous oxide anæsthesia the wounds were explored. When the rubber tube was removed and the middle palmar space was exposed, it was seen that the flexor tendons of the ring finger were completely divided with a loss of one-half inch of the tendons. The synovial sheath distal to the point of division was filled with pus. The head of the fourth metacarpal was necrotic and forming a sequestrum.

The tendon sheath was widely opened by a lateral incision, the necrotic head of the fourth metacarpal removed, and the wound lightly packed with petrolatum gauze. Continuous warm, wet boric dressings were applied for 48 hours; on the third day Carrel tubes were laid in the wounds and the tubes were irrigated every 2 hours with Dakin's solution.

Recovery was slow but uneventful. April 28, 10 days after the last operation, the patient left the hospital, and the wounds were completely healed May 15. At the time of healing passive movement was possible at the fourth metacarpophalangeal joint, but active flexion of the ring finger was impossible because of the division and partial loss of substance of the flexor tendons of the finger.

CASE 13. C. D., Northwestern University Surgical Dispensary, 29036 (June 11, 1930). This patient, a young man of 26 years, was held up on the evening of June 8, 1930, and while struggling struck his right fist against the assailant's mouth, and received a lacerated wound over the proximal interphalangeal joint of the right finger. A few hours later the wound was treated by a physician who sutured the skin and applied a splint to the finger. Early the next day, but a few hours following the injury, the hand began to give him considerable pain and became swollen. This discomfort persisted until June 11 when it became so severe and of such a throbbing intensity that he came to the Northwestern University Surgical Dispensary for relief. At the time of admission the patient's temperature was 100.6 degrees F., the dorsum of the right hand and the ring finger were markedly red and swollen and the epitrochlear glands were palpable and tender. The sutures were removed from the wound, with a resulting discharge of pus, and hot, wet dressings were applied.

On June 12 the temperature was still elevated (100.4 degrees F.), the redness and swelling had diminished somewhat but there still was considerable discharge. On June 13 the temperature at the time of his visit to the dispensary was 99.4 degrees F., the swelling had diminished considerably and the glandular enlargement had disappeared. The hot dressings were continued for another 24 hours.

The general œdema of the hand had subsided by June 16 and did not return thereafter, but discharge from the wound over the proximal interphalangeal joint persisted. When the finger was moved a definite grating was heard in the joint.

A roentgenogram made June 18 showed some increased density of the middle phalanx suggestive of a periostitis. The man was advised to soak the hand twice daily in hot, sterile water and under this treatment the swelling and discharge receded, but never entirely disappeared. From time to time the wound would close; redness, swelling, and pain would appear and persist until drainage was again instituted.

July 16 the patient went swimming with a resulting "flare up" of the infection and increased swelling and redness. Hot packs applied for 24 hours resulted in diminution of the acute symptoms though the discharge persisted. A roentgenogram made July 17 showed nothing different from the previous examination.

He was first seen by us on August 2, at which time there was a marked indurated swelling about the proximal interphalangeal joint, which was held at an angle of about 160 degrees. Motion in the joint was possible through an arc of about 15 degrees. The wound was entirely closed and there had been no discharge for several days. The man was advised to continue with hot soakings of the hand twice daily and to report back to the dispensary at once should an acute swelling develop. An anaerobic culture was requested if at any time the wound should discharge. On August 7 swelling again occurred and a fluctuant area developed on the

dorsum of the joint. This ruptured and a moderate amount of pus discharged from the wound. Unfortunately, due to an oversight, a culture was not procured. On August 9 the swelling had receded and the discharge had ceased. Anaerobic cultures were made from the granulating surface but no growth resulted. On August 15 the swelling and pain reappeared and the man was sent from the dispensary to St. Luke's Hospital on the service of Dr. C. G. Shearon. Dr. Shearon made a large incision through the area of swelling and fluctuation. A localized focus of pus was evacuated and tissues about the joint and bones were seen to be markedly œdematous. Hot moist packs applied for several days lead to a rapid abatement of the pain and swelling. Cultures made of the pus yielded a hæmolytic streptococcus and an unidentified gram negative bacillus which was not bacillus fusiformis. The patient was discharged from St. Luke's Hospital and reported back to the dispensary for observation. He was last seen August 30 at which time the incision had healed, the swelling about the joint was slowly receding and the joint could be moved a few degrees without pain.

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TUMORS OF THE PAROTID GLAND

A Study of Two Hundred and Twenty-Five Cases with Complete End-Results in Eighty Cases

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THIS report is based on a study of 225 cases of parotid gland tumor, taken from the records of the Massachusetts General Hospital and the Collis P. Huntington Memorial Hospital. As the cases date back to 1872, many of them are incomplete in respect to pathological report or follow-up data, and such cases have been excluded except in the very general summaries as to sex, right or left side, etc. In 80 cases, however, the records are complete, including pathological report and follow-up. In most of these cases we have personally studied the microscopic slides, and in all doubtful ones have consulted with Dr. Tracy B. Mallory, pathologist to the Massachusetts General Hospital, to whom we are much indebted for his valuable assistance.

ETIOLOGY

There has always been dispute as to the origin of mixed tumors. By mixed tumors we mean benign growths of varying histological structure, as distinct from carcinomata and sarcomata. Ewing summarizes our knowledge of their origin as follows: "(1) The endothelial origin has been disproved. (2) No single source of the mixed tumors meets all the requirements. Some are distinctly adenomatous, and probably arise from the acini and ducts of the gland in which they are well incorporated. Others are encapsulated or extraglandular and take the form of basal-cell or adenoid cystic epithelioma. These probably arise from misplaced and, occasionally, embryonal portions of gland tissue. Branchial remnants may possibly be connected with this group. (3) The derivation of mucous tissue and cartilage from gland epithelium has been satisfactorily proved, and there is no necessity of including in the originating tissue any cartilaginous structures. . . ."

In discussing complex tumors of the salivary glands, Wood writes as follows: "There is a peculiar group of tumors which occur in the salivary and lacrymal glands, in the palatal region, in the lips, and occasionally elsewhere, all of which have similar structure and are not closely related in morphology with any of the well known types of tumors. They are considered under the fibro-epithelial group, though as they probably arise chiefly from malformations and displacements during embryonic life, they are by many authors classed with the teratoid tumors."

Fry has recently studied the pathology of a series of mixed tumors with reference to their structure and origin. He concludes: "(1) The so-called mixed tumors of the salivary glands are not in reality mixed, but are entirely epithelial in origin. They are in most cases derived from the ducts of the gland, but occasionally arise from the secreting cells. (2) The mucinous material which is such a prominent feature of most of these tumors is a true secretion of mucin by the tumor cells, and this is only an exaggeration of a normal function of the gland cells. (3) The tumors do not contain cartilage. In the substance which has been described as cartilage, the matrix is formed by a change in the mucin of the tumor, whereby it loses its fibrillar appearance and its power of staining deeply with mucicarmine; the cells are epithelial cells. (4) Some of the tumors show varying degrees of malignancy; there is no definite dividing line between the innocent and malignant, and some of the more malignant may show many of the features typical of the innocent type of tumor."

We have studied the subject from a clinical rather than a pathological standpoint and cannot add anything to the theories mentioned as to the origin of mixed tumors. Trauma as a possible etiological factor has

been considered unimportant by most present day observers. In our series there was a history of trauma in only 6 cases, most of which were mixed tumors. In 2 other cases the tumor followed mumps. In one carcinoma case the tumor appeared soon after the patient was kicked in the parotid region by a horse. In 9 cases there was a history of cancer in the family. Many of the cases in this series may not have been questioned as to trauma or as to family history of cancer; in any event, the percentages of traumatic origin or familial cancer must be low, and we do not believe that these are factors of great importance in the etiology of parotid tumors.

PATHOLOGY

Ewing classifies all tumors of the salivary glands under the heading of epithelial tumors, and divides them into three groups, as follows: (1) benign adenoma; (2) malignant adenocarcinoma or carcinoma; and (3) autochthonous mixed tumors. . . .

"Adenoma of the salivary glands is rare. . . ." In none of our series was the diagnosis of adenoma made. McFarland (6) has recently reviewed many cases of supposed adenoma of the salivary glands and says in conclusion: "The newly reported case with which this contribution opens is probably as much like adenoma and as much like a salivary gland as any, but, as was pointed out, is really very little like either. The same seems to be true of all. Upon careful comparison with the gland itself, very little resemblance can be found, and one remains in doubt whether real adenoma of the salivary glands occurs. If so, it must be very rare, for there can be but little doubt that nearly all, if not, indeed, all, of the described adenomata are but mixed tumors of unusual appearance." Certainly our experience is in accord with that of McFarland. To continue with Ewing's classification—

"Carcinoma. Pure malignant epithelial tumors of the salivary glands are by no means rare. . . . The carcinomata usually develop rapidly, and while at first they may be encapsulated, they soon invade the whole gland, the capsule, and regional nodes. . . . After extirpation, prompt recurrence is usually observed. . . . In advanced cases there are local and general metastases, and in Nasse's case many bones were involved." Our carcinoma cases as a rule recurred soon after operation, invaded the glands of the neck, and in 2 cases metastasized to the lungs. We have in our series no record of distant metastasis other than these two to the lungs.

Mixed tumors are classified by Ewing as follows: (1) myxochondrocarcinoma; (2) basal-cell carcinoma with hyaline stroma; (3) adenoid cystic epithelioma.

We have always regarded mixed tumors as benign and find the use of the term carcinoma, as applied to mixed tumors, somewhat confusing. Malignant tumors in our series have all been classified as either carcinoma or sarcoma, although it has been recognized that many of them contain a great variety of tissues. Ewing has little to say about sarcomata of the parotid, apparently feeling that they represent recurrences, for he says, "spindle cell, round cell and perithelial sarcomata have been observed after extirpation of chondrocarcinoma, and it seems probable that most of the so-called sarcomata of the salivary glands are atypical epithelial growths (Menetrier, Chevassu, Wood). Rarely these large cell sarcomata are pigmented, but they lack the malignancy of true mælanoma." We have a number of cases which we believe to be primary sarcoma of the parotid—one of them a mælanotic sarcoma (T. B. Mallory). This case bears out Ewing's statement as to their relatively benign character, for it occurred in a woman of 49 years (Case 71), who lived 9 years after the growth was excised, dying of pulmonary infarct and chronic cardiac disease. Whether this patient ever had any recurrence after operation is not known, as the only subsequent information obtainable was the record of her death. Clinically, it was probably not very malignant, for the operating surgeon records having developed a capsule, and the pathologist describes the specimen grossly as "a cherry-sized cyst, purplish red, with soft center."

The term mixed malignant tumor has not been used in this series, as it has seemed possible to classify all malignant tumors as either carcinoma or sarcoma. There prob-

ably are, however, certain tumors that cannot be so definitely classified, but we believe they are not common.

OCCURRENCE

Age. Parotid tumors may occur at any age, the youngest patient (Case 21) having been only 9 years old at the onset of its growth, which proved to be a mixed tumor; and the oldest patient (Case 53) having been 72 years of age at the time of onset of a carcinoma.

Benign tumors are more apt to begin before the age of 40, whereas malignant tumors usually begin after the age of 40. Table I shows the age of onset in 167 cases.

Sex. Tumors of the parotid are almost equally divided between the sexes, in our series there being a slight preponderance of males; 110 males to 93 females. In the 80 cases with a positive pathological diagnosis, however, there are 2 more females than males.

Right or left side. McFarland has found parotid tumors more common on the left side, but in our series, out of 161 cases, 83 were on the right side, and 78 on the left.

SIGNS AND SYMPTOMS

The diagnosis of parotid tumor is usually easy, but to differentiate clinically the benign from the malignant is difficult and often impossible.

Duration. In 38 mixed tumor cases the average duration of the tumor before entering the hospital was slightly over 7 years. The longest duration was in a woman of 48 years (Case 10), who said she had had the tumor "always." Only 2 patients had had the tumor for less than 1 year. In 30 *cancer* cases the average duration of the tumor was 4½ years, the longest duration being 30 years (Case 73). There were, however, 14 patients, who had had symptoms for less than 1 year. In 9 *sarcoma* cases, there were 6 patients who came to operation within 6 months after first noticing the tumor, the 3 others coming after 2, 16 and 30 years, respectively. It seems evident, therefore, that patients with malignant disease come to the hospital much sooner for advice than do those with benign tumors. The greater rapidity of growth of malignant tumors, often observed by the patients themselves, may thus be an important factor in the diagnosis.

TABLE I.—AGE OF ONSET BY DECADES

	Mixed tumors	Carcinoma	Sarcoma	Unknown pathology	Total in each age group
1–10	1	0	0	0	1
11–20	5	0	1	13	19
21–30	9	3	0	25	37
31–40	13	2	4	17	36
41–50	4	11	2	12	29
51–60	3	6	3	14	26
61–70	1	5	1	4	11
71–80	0	2	0	2	4
Total no. of cases.	36	29	11	87	163

TABLE II.—SEX

	Males	Females
Unknown pathology	71	52
Mixed tumors	18	22
Carcinoma	15	15
Sarcoma	6	4
Total	110	93

TABLE III.—SIDE INVOLVED

	Right	Left
Unknown pathology	46	37
Mixed tumors	20	18
Carcinoma	12	18
Sarcoma	5	5
Total	83	78

Pain. Of 39 patients with *mixed tumors* 32 had no pain. Of the 7 remaining, only 1 had really severe pain, 1 had steady dull pain at night, and 2 complained of pain on movement of the jaw. In patients with *malignant tumors*, on the other hand, pain was much more common, being present in 16 out of 30 cases, and variously described as "cramp-like," "very severe," "unbearable for past 2 weeks," "neuralgic," and sometimes radiating to the head, face, neck, jaw, eye, and back of the ear. The 11 cases with malignant growth treated at the Huntington Hospital are not included in the 30 mentioned cases as they are in a little different group, having often been seen in advanced stages of the disease when pain would naturally be expected, and being suitable cases only for X-ray or radium treatment. In 3 of these latter cases, there is no note as to pain; 2 had no pain at all; 2 had occasional or very little pain; and 4 had very severe pain, particularly in the late stages. Pain is thus

very common in patients with malignant tumors, both early and late in the disease, but relatively rare in patients with benign tumors. Pain is probably due to pressure on the fifth nerve, and is, therefore, to be more commonly expected in large tumors.

Size. The largest tumor in this series was "twice the size of a fist"; it was a sarcoma, of 30 years' duration, in a man 72 years old (Case 66, Fig. 1). He was operated upon in 1889, the common carotid artery ligated, and an extensive operation performed, resulting in his death 3 days later from shock and paralysis. The largest parotid tumor on record, according to McFarland, was one reported by Conterill.[1] McFarland says: "It was more than twice the size of the patient's head, and is said to have weighed 26 pounds. It was not operated upon." The most common size seems to be that of an English walnut; the smallest tumor described being the size of a peanut. Several *mixed tumors* of 10 to 20 years' duration are described as walnut-sized, while a number of *malignant* tumors of only a few months' duration are already as big as a small apple. The greater rapidity of growth of malignant tumors is thus strikingly shown.

Consistency. Practically all parotid tumors are described in the records as hard. Consistency, therefore, gives us very little aid in the clinical diagnosis between benign and malignant tumors. A few mixed tumors may be of the "consistency of a lipoma," "tensely fluctuant," or "partly fluctuant." We feel that there are probably different degrees of hardness, and that, with enough experience, the stony hardness of malignancy may be helpful in the diagnosis, and that a definitely soft tumor is likely to be benign.

TREATMENT

The treatment in practically all cases should be operative. Radium or X-ray treatment in our experience has been only palliative, never curative. Moreover, without operation, no pathological report is obtained, so that, not knowing with what type of tumor we are dealing, the treatment may be unsatisfactory, and no conclusions can be drawn from it. In a very large malignant tumor, in which there is no hope of cure, radium or X-ray may be used, but is chiefly valuable in recurrent malignant tumors. We are aware that some surgeons may have a higher regard for radiation treatment than we have, but certainly in this relatively large series of carefully followed cases, there is no evidence for attributing the permanent cure of a single parotid tumor to the use of X-ray or radium.

OPERATIVE TREATMENT

The ideal procedure is to have a competent pathologist at one's elbow ready to advise and to make a frozen section diagnosis on a small piece of tumor tissue removed for biopsy. Then, if the report is a benign tumor, the facial nerve will not be needlessly sacrificed; but if the report is malignant, it should be sacrificed if necessary without a moment's hesitation, and a very extensive removal of the entire parotid gland, together with a complete neck dissection, should be done. All too often, we believe, has an incomplete operation been performed, saving the facial nerve, but not curing the disease. Sometimes it may be necessary merely to do a biopsy at the first operation, waiting a few days for a fixed section report before continuing with the operation. This procedure, while it subjects the patient to two operations, enables careful study by the pathologist of a stained specimen and will be more satisfactory than a doubtful frozen section diagnosis.

At the time of operation the question of *encapsulation* may be of importance and should be noted by the surgeon. Encapsulated tumors are more likely to be benign, but care should be exercised not to rupture the capsule in removal, as spilling of the contents may be the source of a recurrence, which may be malignant, though probably more often the recurrence will be mixed tumor, if the original growth was mixed tumor. We have only one case in our series which started as a mixed tumor and later recurred as a carcinoma (Case 42); in this case definite mention was made by the surgeon at the first operation of the capsule

[1] Scot. M. & S. J. 1907, xx, 526.

breaking and "mushy contents" squeezing out. The history of the case is as follows:

First admission. E. C. T., a man of 46 years, entered the Massachusetts General Hospital on October 15, 1890, complaining of a lump, of 10 years' duration, in front of the right ear. The lump had been growing slowly until the last few years when it began to increase more rapidly and a second lump appeared below the first. There had been no pain. Local examination showed a bilobar tumor, the size of a turkey's egg, situated in front of and extending a little below the right ear. The skin over it was freely movable and unaffected. The tumor was hard, firm, and elastic, and not firmly attached below. The upper lobe of the tumor was about twice as large as the lower.

Operation. A semicircular incision was made through the skin over the tumor, which was found to be enclosed in a firm capsule. The tumor was nearly enucleated when the capsule broke and the soft mushy contents squeezed out. The rest of the capsule was adherent and was scraped out with a curette. The incision was sewed up with general drainage. The facial nerve was not exposed.

Pathological examination. A large irregularly rounded growth with a translucent bluish white section surface dotted with opaque yellow white spots. Microscopic examination showed a basis of hyaline cartilages with here and there areas of fatty degeneration, and remnants of gland tissues. Enchondroma. Follow up note February 27, 1901. Patient is in perfect health as far as parotid goes.

Second admission. On May 22, 1903, at the age of 59 years, the patient re-entered the hospital. There had been no sign of tumor until 2 years ago, when it reappeared, grew slowly until 2 months ago, since which time it had increased rapidly in size. It had given rise to very little pain. Local examination showed a firm, regular, movable tumor, about the size of an egg, just below the lobe of the right ear and extending slightly below the angle of the jaw. The skin over the most prominent part was reddened and tense. There was no tenderness or pain on pressure.

Operation. An incision was made over the prominent portion of the tumor, the growth exposed, and found to be probably malignant. Further dissection was considered inadvisable because of the extent of the infiltration. The surface of the growth was removed to give more favorable opportunity for X-ray treatment.

Pathological examination. A small piece of rather firm glandular-looking tissue, which, on microscopic examination, showed solid masses of large epithelial cells, separated by a meshwork of fibrous tissue. Cancer.

Patient died of cancer in July, 1904, 14 months after the last operation.

In operating on malignant parotid tumors it has often been necessary to ligate the external carotid artery and the internal jugular vein, and occasionally the common carotid artery has been ligated.

Ligation of the external carotid artery is a very useful procedure, and one which is frequently carried out at the present time in malignant tumors. When the vessel is ligated early in the operation, there is much less hæmorrhage. As far as we know, there is never any harmful result from ligation of this artery. Ligation of the jugular vein is also useful and has not resulted in any damage in these cases.

Ligation of the common carotid artery, on the other hand, is an unnecessary procedure in the operation for parotid tumor, never employed nowadays, and is very dangerous. In our series, this vessel was tied in 5 cases, with no damage in 2 but with very serious results in the 3 others. The first patient (Case 40) to survive was a man of 36 years, who had a very extensive operation done in 1903, for what, at that time, was called a sarcoma of the parotid, but which, we now believe, on reviewing the microscopic slides, was a mixed tumor. This patient is now living and well. The only other patient (Case 49) to survive this ligation was a man of 51 years, operated on in 1895, who, as far as we can discover from the record, suffered no ill effect from the ligation, but who died 14 months later of carcinoma. In the 3 fatal cases, the damage resulting from a diminished blood supply to the brain was immediately evident. These patients were, on the whole, somewhat older, and probably the condition of their blood vessels was relatively poorer. One of these (Case 48) was a woman of 57 years, with a left sided carcinoma, who, after ligation of the common carotid, suffered a right cerebral monoplegia with paralysis of the right arm, aphasia, and astereognosis, and died 5 months after operation, of carcinoma. Another patient, a woman of 44 years (Case 65), with a right sided sarcoma, suffered cerebral anæmia with œdema and softening of the right cerebral hemisphere, and died 8 days after operation, of hæmorrhage. The third fatal result occurred in a man of 72 years (Case 66) who had a left sided sarcoma, and who died 3 days after

operation, of "shock" and paralysis of the right arm and leg. In Gray's *Anatomy* it is stated that "after ligature of the common carotid, the collateral circulation can be perfectly established by the free communication which exists between the carotid arteries of opposite sides, both without and within the cranium, and by enlargement of the branches of the subclavian artery on the side corresponding to that on which the vessel has been tied. The chief communication outside the skull takes place between the superior and inferior thyroid arteries, and the profunda cervicis and ramus descendens of the occipital; the vertebral takes the place of the internal carotid within the cranium." That the circulation to the brain, however, is frequently inadequate after such a ligation, is well shown by the 3 cases cited. Bevan and McCarthy, in studying tumors of the carotid body, observed 25 cases in which the common carotid artery was ligated, with a 30 per cent mortality. The mortality in our series of only 5 cases was 60 per cent. Reid and Andrus, writing on the surgery of the arteries, conclude that "ligation of the external carotid artery does not cause any risk of gangrene to the face or head, and will not produce cerebral disturbances except when, rarely, a thrombus extends back into the common carotid, thus causing its occlusion or resulting in emboli to the brain. Ligation of the common carotid should never be performed when ligation of the external carotid artery will suffice. There should really be no danger in ligating the external carotid artery."

Damage to the facial nerve, as previously noted, is frequently inevitable in operations for malignant disease of the parotid. As soon as it is certain that we are dealing with malignancy, the facial nerve should be sacrificed if necessary, without further consideration. In only 11 cases in our series was the facial nerve cut; a very small proportion, and probably partly responsible for the poor results obtained. Whether or not more cases would have been cured by disregarding the facial nerve, is, of course, problematical, but we feel very strongly that in most of them the chance should have been taken. Severing of the facial nerve results in disfigurement to be sure, but in the natural progress of cancer the nerve would soon be destroyed anyway. In this connection Wood says "most of the failures to obtain permanent cures are due to the close relationship of the parotid type (of salivary gland tumor) to the facial nerve. The surgeon, faced with the dilemma of a facial paralysis or an incomplete removal of the growth, frequently chooses the latter, but when the tumor returns paralysis often follows from pressure on the nerve. Radiation at this time may only increase the paralysis by its sclerosing effect on the connective tissue of the scar." In our series there was one case with carcinoma in which the spinal accessory nerve as well as the facial nerve was cut; this was in a man only 28 years old (Case 46) with an apparently rapidly growing cancer, which recurred, and caused his death 6 months after operation. In one mixed tumor case (Case 25), the facial nerve was purposely cut to facilitate removal of the tumor, and was then sutured together, with only very temporary facial paralysis as a result. In several cases in which the facial nerve was cut or severely traumatized at operation there was complete facial paralysis for several months, which later cleared up entirely.

TREATMENT BY RADIATION

We believe that radium and X-ray treatment are useful only as palliative procedures. As far as we know, no parotid tumors have ever been cured by radiation. Simmons' opinion is as follows: "In the cases in which surgical treatment is not indicated, radiation gives very satisfactory results; the tumor shrinks and becomes hard and fibrous, but rarely disappears entirely. . . . Radium is apparently of more value than the X-ray, and treatment by gold or platinum seeds is to be preferred." Duane and Greenough comment on the use of radium as follows: "Among the earliest observations of the effect of radium on tumor growth, there were reported instances of its favorable action upon mixed tumors of the parotid gland. These reports have come from many sources, and there is little doubt that favorable results have been obtained. This phenomenon, however, is not constant, and in our own

experience we have seen a number of parotid tumors which were apparently unaffected by radium treatment." As previously mentioned, the difficulty in evaluating the results of radiation treatment is chiefly because of the lack of a pathological report. Twenty-three such cases were treated at the Huntington Memorial Hospital with X-ray or radium or both. A number of these cases had also had an excision of the tumor performed elsewhere, but no satisfactory pathological report had been obtained. Low and high voltage X-ray were each used at times, but radium was felt to be more effective, and was, therefore, used in practically all the cases. The usual X-ray dosage was 800 r units to each side of the face and neck, repeated about every 2 months. Radium was given in the form of steel radon tubes, usually at a distance of 2.5 centimeters from the tumor, and screened with 0.5 millimeter of lead; glass or gold seeds were also used in almost all cases. The total dosage at any one treatment averaged between 2,000 and 2,500 millicurie hours. Treatments were generally given at monthly intervals, some patients receiving only a few, but many receiving up to twenty or more treatments with and without X-ray.

The *results* of radium treatment in these 23 patients are summarized in Table IV.

TABLE IV.—RESULTS OF RADIUM

	Cases
Died	8
Living—nodules still present	8
Had excision as well as radiation	16
Apparently cured (diagnosis doubtful)	2

Many of the same patients have been counted more than once in this summary.

Of the patients who died, there is little to be said, except that most of them died within 6 months after radiation treatment was begun, and all died within 2 years. They undoubtedly had malignant tumors, although pathological proof is lacking in all of these cases.

In regard to the second group, it might be said that the nodules remaining after treatment are merely scar tissue, but some of them seemed to be growing larger when last seen. Only further excision and microscopic examination would answer this question.

Concerning the third group, we feel that no conclusions can be drawn regarding the benefit from radiation. In a number of these cases, radium or X-ray was merely used as a prophylactic postoperative measure, and the credit for a good result must go chiefly to the surgeon, as most benign parotid tumors are cured by surgery alone.

On further examination of the records there is also considerable doubt about the fourth group, which comprises only two cases, for in the first of these there had been a radical neck operation at another hospital, 6 years prior to the radium treatment for supposed mixed tumor of the parotid, making it possible that the parotid lesion was a part of the original process in the neck, whatever that may have been; and in the second case, the tumor of the parotid, which was felt clinically to be more inflammatory than mixed tumor, was getting rapidly smaller for 2 months before radium treatment was instituted. Evidence that radium and X-ray treatment are useful palliative procedures is contained in many of the records, but proof that radiation therapy has cured any parotid tumor in this series is lacking.

PROGNOSIS—MIXED TUMORS

In the mixed tumor group the prognosis as to life is good, although recurrence takes place several times in many instances. Of 40 mixed tumor cases, in only one patient did a mixed tumor later become malignant. This case has been referred to already. The 39 other patients have all lived at least 5 years after the last operation, with the exception of 4 cases followed only 2, 3, 4, and 4½ years, respectively.

Recurrence. Mixed tumors, do, however, recur not at all infrequently, but the recurrence is almost always benign. Two patients have had a recurrence but have refused further operation.

CASE 21, a boy of 16 years, entered the Massachusetts General Hospital in January, 1919, having had a tumor in the right parotid region for 7 years. This had been excised once in 1915 by his own doctor. Operation was performed and the tumor was removed. The pathological report was mixed tumor. Recurrence took place 2½ years later and was treated eight times with radium at the Hunt-

ington Memorial Hospital, beginning in 1922. Treatments were given at intervals of 4 to 6 weeks, the dosage varying from 1,296 millicurie hours to 3,530 millicurie hours, the usual dose being about 2,000 millicurie hours. Steel radon tubes were used each time, usually about four of them, at a distance of 2.5 centimeters from the lesion, and screened with 2 millimeters of lead. Careful notes were kept at each treatment, and little or no change in the lesion was observed at any time. In 1926 a letter was received from the patient stating that the size of the tumor was just the same. In 1927 a partial removal of the tumor was done by a surgeon in New Hampshire. In 1928, when he was again seen at the Huntington Memorial Hospital, eight shotty nodules were still present.

The other case (Case 27) gives a similar history of operation at the Massachusetts General Hospital in 1914, the microscopic examination showing a mixed tumor. Eight radium treatments were subsequently given at the Huntington Memorial Hospital in 1922, the dosage and manner of treatment having been similar in every way to that given in the first case. Just before the seventh treatment it was noted that there was certainly no decrease in the size of the tumor, and a month later there was thought to be possibly a slight extension of the growth. This patient was seen by us in 1928, 5 years after her last radium treatment, at which time she had a firm, hard mass in the right parotid region the size of an English walnut. Operation was advised, but refused.

We thus have evidence, in these 2 cases at least, of the ineffectiveness of radium in proved mixed tumors.

Of 40 cases, 36 lived over 5 years after the last operation, 21 over 10 years, 6 over 20 years, and 3 over 30 years. The follow-up statistics could not cover any longer periods of time in these cases because of the deaths of 12 patients from other causes, and because of the comparative recency of many of the operations.

Twelve patients in the 40 mixed tumor cases, or 30 per cent, had one or more recurrences. Five of the 40, or 12.5 per cent, had two recurrences. There were thus 17 recurrences in 40 cases, or 42.5 per cent. Of all these recurrences, however, only one was malignant. Judging from our series, therefore, there is one chance in 40 (2.5 per cent) of a mixed tumor recurring as a malignant tumor; and one chance in twelve (8.3 per cent) of a *recurrent* parotid tumor, previously reported microscopically as mixed, proving to be malignant.

The length of time recurrence was noted after operation is not recorded in all cases, but varies from immediate recurrence to 5 years after operation. The number of years elapsing between operations was never less than 2, and was often 5 or 10, being 16 in 1 case and 20 in another. In 5 cases in which recurrence took place, it was noted at the time of operation that the tumor was not completely removed. In 4 cases in which the tumor recurred immediately, it grew so slowly and caused so little discomfort that further operation was postponed by the patient for 9, 10, 13, and 20 years, respectively.

Ewing discusses the clinical course of mixed tumors as follows: "In the great majority of cases a quiescent tumor has long preceded the development of an active growth. Very often the quiescent nodule was observed for 8 to 10 years, Pailler reporting an inactive period of 37 years, and Wood 53 years. Trauma rarely appears as a possible factor. Once established, active growth proceeds slowly, but varies with the histological type. . . . Surgical removal is often followed by recurrences of increasing malignancy. On the other hand some old tumors, becoming active, soon infiltrate the capsule and gland, and even invade the lymph nodes in a few months. . . . After surgical interference encapsulated growths do not, as a rule, recur, but others are very prone to return at once or after an average interval of 2½ years, or as late as 9 years. In Wood's 37 cases, there is a record of 17 recurrences (45 per cent) while 12 cases were checked by a secondary operation, and 20 (55 per cent) were permanently cured. Successive recurrences with many operations have extended over a period of 20 years (Wood) and 23 years (Billroth). In the recurrent tumors the structure may remain constant, but more often it becomes increasingly cellular, atypical, and malignant." Our percentage of recurrences (42.5 per cent) agrees very closely with Wood's (45 per cent). We have also records of successive recurrences extending over more than 20 years, and have a record of 1 patient, who had three operations and is now living 51 years after she first noticed the presence of the tumor.

PATHOLOGICALLY MIXED TUMORS—

Date	Identification	Age on admission	Age at onset	Sex	Duration	Right or left	Pain	Size	Consistency
9-20-15	1 E.S.203317	53	28	F	25 yr.	L	None	Tennis ball	Hard
8-8-18	2 W.S.224164	67	57	M	10 yr.	L	None	3x3x2 cm.	Warty, hard
12-12-24	3 W.S.266924	46	?	F	?	R	None	Hen's egg	?
11-20-23	4 256694	45	40	M	5 yr.	L	None	Bean	?
2-19-00	5 S.S.V.40 P.252	42	37	M	5 yr.	R	None	3.5 cm.	Hard
9-23-19	6 E.S.232760	51	50	F	18 mo.	?	?	2x2x3 cm.	?
5-5-21	7 W.S.242909	30	26	F	4 yr.	L	Severe pain in tumor	Hen's egg	Hard
5-8-24	8 M.S.262844	47	45	F	2 yr.	L	Yes, on mastication—frequent shooting pain	Walnut	Part firm, part fluctuant
10-20-15	9 W.S.204848	60	53	F	7 yr.	L	None	Pullet's egg	Firm
11-30-17	10 W.S.218954	48	?	F	*Always*	R	None	Tennis ball	Consistency of lipoma
5-1-13	11 W.S.188891	72	68	M	4 yr.	R	None	Hen's egg	Hard
5-12-16	12 E.S.208329	38	31	M	7 yr.	L	None	Large peanut	Firm, elastic
7-6-20	13 E.S.237496	43	33	M	10 yr.	R	None	Fist	Tense, fluctuant
10-20-21	14 E.S.245945	39	23	M	16 yr.	R	Never	Large orange	Hard
1-15-21	15 W.S.240836	36	31	M	5 yr.	R	None	Silver dollar	Hard
5-27-22	16 E.S.249978	22	15	F	7 yr.	R	None	Almond	Firm
7-11-24	17 W.S.264125	42	34	M	8 yr.	L	Yes	English walnut	Deeply fluctuates
8-8-05	18 W.S.143831	50	34	F	16 yr.	L	None	Egg	Hard
8-17-00	19 W.S. Vol. 363, p. 82	40	38	F	2 yr.	L	None	Horse chestnut	Firm; hard
5-19-97	20 S.S. Vol. 20, p. 8	50	45	M	5 yr.	R	None	Walnut	Hard
1-6-19	21 W.S.227488	16	9	M	7 yr.	R	None	Lemon	Hard
5-19-17	22 W.S.215021	48	31	F	17 yr.	L	None	Walnut	Smooth
4-12-17	23 E.S.227343	34	32	F	2 yr.	L	None	Marble	Hard

MASSACHUSETTS GENERAL HOSPITAL CASES

Operation	Encapsulated or not capsule broken	Vessels ligated and damage caused	Nerves damaged	Length of life after last operation	Length of life after first noticed	Recurrence	Radium or X-ray treatment	Remarks Cause of death as on death certificate
Excision	Yes. Shelled out		None	14 yr.	39 yr.	None		
Excision	Yes			3 yr.	13 yr.	None		Died of pulmonary embolus after posterior gastro-enterostomy for duodenal ulcer
Excision	Yes			4 yr.	?			
1. Excision and drainage 2. Excision	Removed intact without rupture			4 yr.	9 yr.	4 yr. None		
Excision	Circumscribed. Shelled out			5 yr.	10 yr.			Drowned 5 yr. after operation
Excision	Yes			9 yr.	10½ yr.			
1. Biopsy 2. Excision	Cystic			8 yr.	12 yr.	None		
Excision	Yes. Capsule not broken			5 yr.	7 yr.	None		
Excision	Yes; tumor broken into at 1 point			5 yr.	12 yr.			Died 5 yr. Cardiac
Excision	Shelled out; ruptured at upper pole			6 yr.	"Always"			Died 5 yr. Gastric ulcers
Excision	Encapsulated but not definite at lower pole			7 yr.	11 yr.	None		Died 7 yr. Heart failure
1. Excision 5 yr. ago 2. Excision	No. "Great difficulty"			6 yr.	13 yr.	None		Died 6 yr. Tuberculosis
1. Excision 10 yr. 2. Excision 3 yr. 3. Excision			Right facial paralysis	8 yr.	18 yr.	None		
Excision				7 yr.	23 yr.	None		
Excision	Yes			7 yr.	12 yr.	None		
Excision	Partially encapsulated			6 yr.	13 yr.			
Excision	Yes. Capsule ruptured			5 yr.	13 yr.	None		
Excision 1. 12 yr. ago in Lawrence 2. Excision	Almost completely encapsulated			6 yr.	22 yr.			Died 6 yr. Burned to death
Excision	Shelled out			13 yr.	15 yr.			Died 13 yr. Cancer breast
Excision	Yes			19 yr.	24 yr.			Died 19 yr. Heart disease
1. Excision in Keene, N. H., 1915 2. 1918 3. Excision Mass. Gen. Hosp. 1919				9 yr.	16 yr.	Yes, Apr., 1928. 8 shotty nodules still present	8 Radium. X-rays at Huntington	
Excision	Enucleated, friable and partly broken up			10 yr.	27 yr.	None		
1. Excision 1917 2. Excision 1918 3. Excision 1927	Yes; capsule partly removed			2 yr.	14 yr.	Yes but not since last operation. Salivary fistula for 2 wk.	No	Slight break in capsule at last operation. Salivary fistula for 2-3 wk.

PATHOLOGICALLY MIXED TUMORS—MASSA-

Date	Identification	Age on admission	Age at onset	Sex	Duration	Right or left	Pain	Size	Consistency
5–7–10	24 E.S.169758	39	32	F	7 yr.	R	None	?	Tensely fluctuant
5–2–14	25 E.S.195268	24	23	M	7 mo.	R	Yes, for past 2 mo. in lower portion	English walnut	Hard
5–6–18	26 E.S.222258	33	31	F	2 yr.	L	Yes, steady dull pain at night	4x4½ cm.	Hard
4–10–14	27 E.S.194883	28	24	F	4 yr.	L	None	?	Soft; fluctuant
3–19–10	28 W.S.168908	41	?	M	?	?	?	English walnut	?
5–28–18	29 W.S.222699	28	24	F	4 yr.	R	None	2x2½x4 cm.	Hard
11–12–15	30 E.S.205249	30	29	M	8 mo.	L	None	½ walnut	Hard
8–24–16	31 W.S.210151	58	56	M	2 yr.	R	None	Hen's egg	Hard
12–26–13	32 W.S.192977	17	15	M	2 yr.	R	Slight, occasional	10x15 cm.	Hard
6–6–02	33 S.S. Vol. 63, p. 35	30	20	M	(1) 10 yr. (2) 4 yr. recurred immediately (3) 4 yr.	R	?	Cranberries	?
6–20–02	34 E.S.127594	39	?	F	?	L	None	English walnut	?
12–9–96	35 S.S.Vol.15 p. 206	21	19	F	2 yr.	R	None	Peanut	Hard
4–17–93	36 E.S. Vol. 278, p. 243	30	15	F	15 yr. in all 8 yr. present	R	Never	1. Walnut 2. ? 3. Fist	Semifluctuant
4–24–89	37 W.S.162779	28	23	F	5 yr.	L	None	2 oranges	Firm
12–6–92	38 W.S.273 p. 207	27	23	F	4 yr.	R	None	Hen's egg	Hard
12–5–06	39 S.S.150542	34	33	M	10 yr.	R	None	1. Distal phalanx of thumb 2. Quarter	1. Hard 2. Hard
6–16–03	40 W.S.132717	36	34	M	2 yr.	L	Yes, for past week on opening mouth too wide	2½ cm.	Hard

CHUSETTS GENERAL HOSPITAL CASES—*Continued*

Operation	Encapsulated or not capsule broken	Vessels ligated and damage caused	Nerves damaged	Length of life after last operation	Length of life after first noticed	Recurrence	Radium or X-ray treatment	Remarks Cause of death as on death certificate
Excision	Yes; shelled out			18 yr.	25 yr.	None		
Excision	Yes; enucleated		Facial cut and sutured together. *No damage*	14 yr.	14½ yr.	None		Very temporary damage from cutting facial
1. Incision and drainage 6 mo. ago 2. Incision and drainage 3 wk. ago 3. Excision	Yes; capsule ruptured			10 yr.	12 yr.	None		
Curetted				13 yr.	17 yr.	Lump size English walnut	Yes—May, 1922 at Huntington. 8 Gamma	Patient seen; swelling never went away altogether after operation in 1914. Further operation advised but not done
1. Excision 2. Operation outside, Sept. 1924	1. Yes; capsule broken with escape of broken down tissue			5 yr.	19 yr.	Yes but not since last operation 5 yr. ago		
1. Local surgeon 3 yr. ago 2. Excision				10 yr.	14 yr.	None		
Excision	Yes; shelled out			14 yr.	15 yr.	None		
Excision	Yes; easily removed			10 yr.	12 yr.	?		Died 10 yr. Cerebral hæmorrhage
Excision	Yes; easily shelled out			16 yr.	18 yr.	?		
1. Excision 10 yr. Local surgeon 2. Excision 4 yr. Local surgeon 3. Excision. Mass. Gen. Hosp.	3. Shelled out. Broke with escape of cheesy material			27 yr.	37 yr.	3 operations ?		
Excision				25 yr.	25 plus?	None		
Excision	Shelled out			33 yr.	35 yr.	?		
1. Excision 15 yr. ago 2. Excision 13 yr. ago 3. Excision curetted. Mass. Gen. Hosp.	Partly encapsulated. Scooped out; capsule not removed			36 yr.	51 yr.	?		
1. Excision. Local surgeon 1887 2. Excision. Mass. Gen. Hosp. 1889 3. Excision. Mass. Gen. Hosp. 1909	2. Removed piece-meal			12 yr.	37 yr.	3 operations ?		Died 12 yr. after last operation. Myocarditis, Grave's disease
Excision	Yes; adherent; not shelled out			30 yr.	34 yr.	Yes, but was not operated on again; no pain		Died 30 yr. later. Apoplexy
1. Excision 1906 2. Excision 1916	1. Yes; sac opened and caseous material escaped 2. Removed with difficulty in fragments			13 yr.	33 yr.	2 operations; no record after second		
Excision	No	Common carotid. No damage	Facial nerve	26 yr.	28 yr.	No	No	

PATHOLOGICALLY A BENIGN CYST—MASSA-

Date	Identification	Age on admission	Age at onset	Sex	Duration	Right or left	Pain	Size	Consistency
6-22-23	41 E.S.256907	32	33	M	9 yr.	R	None	1. Walnut, small 2. Lemon	Cystic

PATHOLOGICALLY MIXED

10-15-90	42 E.S.Vol.260 p. 32	46	36	M	10 yr.	R	1. None 2. Very little	1. Turkey's egg 2. Egg	1. Hard 2. Firm

PATHOLOGICALLY

7-25-11	43 S.S.177398	59	58	M	1 yr.	L	Yes, cramp-like under left ear	5x4x3 cm.	Hard
9-12-17	44 W.S.217425	45	45	M	7 wk.	L	None	Two lumps, each about size of walnut	?
1-21-25	45 267601	52	41	M	11 yr.	L	Pain 2 mo. Unbearable for past 2 wk.	Large plum	Hard
2-15-09	46 S.S.162457	28	27	M	7 mo.	L	None	Pigeon's egg	?
6-22-16	47 E.S.209082	72	71	M	6 mo.	L	None	Walnut	Firm
8-2-13	48 E.S.190494	57	35	F	22 yr.	L	Yes, at night	2½x3½ cm.	Hard
1-15-95	49 S.S.4 p. 166	51	50	M	9 mo.	R	Yes, right eye and parotid region	½ apple	Firm
2-18-99	50 W.S.Vol.341 p 78	52	50	M	2 yr.	L	No	3 cm.	Hard
9-29-09	51 S.S.166142	62	62	M	2 mo.	R	Yes, right side of neck	6½ cm. diam.	Hard
7-5-05	52 E.S.143278	48	48	M	1 mo.	R	None	4 cm. diam.	Firm, hard
12-8-06	53 E.S.150570	72	72	M	3 mo.	R	Yes, behind right jaw	?	?
6-10-21	54 W.S.243558	67	67	F	10 wk.	L	Sl. neuralgic pain for 3 wk. over left side of face	Small apple	Hard
8-20-01	55 S.S. Vol. 47, p. 216	60	59	F	6 mo.	R	Yes, radiates to ear and under jaw	2x3 inches	Hard
1-29-23	56 254334	56	56	F	3 mo.	L	None	2x3x2 cm.	Hard
5-28-09	57 W.S.164154 W.S.166661	33	32	F	1 yr.	R	Yes, chiefly to neck	4x2 cm.	Hard, elastic

CHUSETTS GENERAL HOSPITAL CASES—*Continued*

Operation	Encapsulated or not capsule broken	Vessels ligated and damage caused	Nerves damaged	Length of life after last operation	Length of life after first noticed	Recurrence	Radium or X-ray treatment	Remarks Cause of death as on death certificate
1. Incision 1919 2. Excision 1923	Cystic			5 yr.	14 yr.	None after last operation		

TUMOR, LATER CARCINOMA

1. Excision mixed tumor 2. Excision, cancer	First operation encapsulated. Capsule broke and mushy contents squeezed out			14 yr. after first operation. 1 yr. after second operation	24 yr.	Yes	?	Cancer. Glands of neck. General sepsis. Pressure on larynx

CARCINOMA

Partial excision	No note	Jugular vein. External carotid. No damage	Partial; no note of damage	3 mo.	15 mo.	Not stated	No	"Angio-sarcoma," neck
Excision	No note	None	None	6 mo.	8 mo.	Not stated	No	General carcinomatosis
Partial excision and implantation of radium done twice	No note	None	None	5 mo. after first operation; 2 mo. after second operation	11½ yr.	Yes	Radium	Recurrence
Excision	No note	None	Facial and spinal access. No note after operation	6 mo.	13 mo.	Yes	No	Recurrence. Venous thrombosis
Excision	No note	None	None	6 mo.	1 yr.	Not stated	No	Carcinoma of neck
Excision	No note	Common carotid. right cerebral monoplegia. Paralysis right arm	Facial	5 mo.	22 yr. 5 mo.	Yes	No	Cancer
Excision curetted. Cautery	No	Common carotid. No note of any damage	None	14 mo.	23 mo.	Yes	No	Cancer of jaw and liver
Excision	No	None	None	1 yr.	3 yr.	Yes	No	Cancer
Excision	Not stated	None	None	1 yr.	14 mo.	Yes	No	Hæmorrhage from cancer
Excision	No	None	None	16 mo.	17 mo.	Yes	No	Cancer of neck
Curetted	Not stated	None	None	11 mo.	14 mo.	Yes	No	Cancer
Excision	Not stated	None	None	7 mo.	9 mo.	Yes	Yes	Sarcoma of neck and mediastinum
Excision	No	None	None	1 yr.	1½ yr.	Yes	No	Epithelioma of face
Excision	No	Jugular vein. External carotid. No damage	Complete left facial	2 yr.	2 yr. 3 mo.	None locally	No	Carcinoma left parotid. Carcinoma lung. Cerebral hæmorrhage
Excision; cauterization, neck dissection 12 operations in all	Yes—first time it was encapsulated. Capsule not broken	None	None	15 yr. after first operation 15 mo. after last operation	16 yr.	Yes, repeatedly	Yes	Cancer of lung

PATHOLOGICALLY CARCINOMA—MASSA-

Date	Identification	Age on admission	Age at onset	Sex	Duration	Right or left	Pain	Size	Consistency
11–10–98	58 E.S. Vol. 344, p. 38	48	47	M	6 mo.	R	No	Walnut	?
7–22–18	59 W.S.223813	62	55	M	7 yr.	L	None	Large walnut	Hard
5–6–10	60 W.S.169740	61	41	F	20 yr.	R	No	Half orange	Hard
10–9–25	61 272457	59	58	F	1 yr.	L	Occasional slight ache	5x3½ cm.	?
8–14–19	62 W.S.232182	60	44	F	12 yr.	L	Very painful	?	Hard

PATHOLOGICALLY

11–15–17	63 W.S.218667	57	56	M	6 mo.	R	None	Almond	Hard
1–20–00	64 S.S.Vol.40 p. 158	32	31	M	6 mo.	R	Yes, severe, rt. neck and behind ear	15x10 cm.	Hard
12–2–18	65 W.S.226770	44	44	F	4 mo.	R	None	5½ cm. diam.	Hard
7–2–89	66 E.S. Vol. 248, p. 116	72	42	M	30 yr.	L	Yes—up left side of head lately	Twice size of fist	Hard
8–30–04	67 W.S.138965	55	55	F	5 wk.	L	Yes—left parotid cheek—shoots to eye	Hickory nut	Hard
3–5–95	68 W.S.299 p. 62	62	62	M	3 mo.	L	None	Hen's egg	?
12–28–09	69 S.S.167582	58	58	M	?	L	None	?	?
4–29–22	70 E.S.249435	33	31	F	2 yr.	R	None	1½ in. diam.	Stringy, soft, vascular
3–12–15	71 W.S.200807*	49	49	F	½ yr.	R	Only at onset severe	Walnut	Hard

*Melanotic sarcoma.

CHUSETTS GENERAL HOSPITAL CASES—*Continued*

Operation	Encapsulated or not capsule broken	Vessels ligated and damage caused	Nerves damaged	Length of life after last operation	Length of life after first noticed	Recurrence	Radium or X-ray treatment	Remarks Cause of death as on death certificate
Excision	Not stated	None	None	2 yr.	2½ yr.	Yes	No	Cancer of face
Excision and cauterization 3 operations	No	None	Facial cut	9 yr. after first operation 2½ yr. after last operation	9½ yr.	Yes	Yes; 21 radium treatments	Endothelioma, parotid gland
Excision	Not stated	None	None	22 mo.	22 yr.	Yes	No	"Sarcoma" of spine
Excision	Lower part encapsulated. Upper part infiltrating		Lower facial	3 yr.	4 yr.	No	No	Living now
1. Albania 1915 2. 1919 3. 1924 4. 1925 Excision every time	No		Facial complete	11 yr. after first operation 1 yr. after last operation	23 yr.	Yes	Yes; 30–40 X-ray treatments without improvement	Gall stones in 1926

SARCOMA

1. Excision 2. Excision of nodule	1. Encapsulated and broken			3 yr. after first operation 3 mo. after last operation	3½ yr.	Yes	No	Recurrent sarcoma, parotid and neck
Excision and neck dissection		Jugular vein. External carotid. No damage		10 days	6 mo.		No	Hæmorrhage
Excision		Common carotid. Anæmia with œdema, and softening right cerebral hemisphere		8 days	4 mo.		No	Hæmorrhage
Excision		Common carotid; shock; paralysis right arm and leg		3 days	30 yr.		No	Shock; paralysis
Excision and curettage	No	External carotid, no damage	Facial	3 mo.	4 mo.	Yes	No	Sarcoma of parotid, cerebral embolus
Portion curetted	No			1 yr.	1¼ yr.	Yes	No	Sarcoma of neck
Excision		Jugular vein, no damage		5 yr. after last operation	?	Yes	Yes	Sarcoma of parotid
Excision	No		Facial; no paralysis	7 yr.	9 yr.	No	No	Now living
Excision	Yes, fairly adherent			9 yr.	9 yr.	?	?	Pulmonary infarct. Chronic mitral disease

PATHOLOGICALLY CARCINOMA—HUNTING-

Date	Identification	Age on admission	Age at onset	Sex	Duration	Right or left	Pain	Size	Consistency
10-19-15	72 15315172	34	30	F	4 yr.	R	Yes, very severe at end	4x5 cm.	Hard
5-25-24	73 24381	52	22	M	30 yr.	L	Yes, very severe at end	6x10 cm.	
4-27-23	74 23409	65	55	F	Mumps 55 yr. ago with tender glands ever since. 10 yr. growing bigger	L	Very little	4 cm. diam.	Hard
3-12-17	75 17106	?	?	F	2½ yr.	R	?	?	Hard
12-21-20	76 201302	50	47	F	3 yr.	L	Occasional	1x3 cm.	?
4-8-22	77 22746	46	45	M	6 mo.	L	No pain, difficulty in swallowing		Hard
11-17-22	78 221457	46	45	F	8 mo.	L	Yes, much at end	5 cm. diam.	Hard
7-7-22	79 22849	67	64	F	3 yr.	R	No	?	?
5-3-15	80 15140	67	66	F	1 yr.	R	Yes, severe Recurrent cancer parotid with lung metastasis, cerebral hæmorrhage. Postoperative shock; lung abscess	Lemon	

Our own feeling is that the prognosis in mixed tumors is rather more favorable than Ewing would lead us to believe. Our cases seem to bear out the ideas of Wood, who says "While these tumors may grow slowly and even remain innocuous for 20 or 30 years, they occasionally undergo changes which are evidenced by a sudden increase in growth rate and rapid involvement of the surrounding tissue, with metastasis to regional nodes. Under these circumstances squamous cell epithelioma and spindle cell sarcoma have been found superimposed on a mixed tumor. Such alteration in type is fortunately rare."

Metastasis. Mixed tumors in this series recurred locally, but never produced distant metastases.

McFarland's (7) conclusions are substantiated by our findings. Among his conclusions are the following:

"They (mixed tumors) are inherently benign, but commonly recur after excision, and if frequently disturbed become locally destructive and invasive, without giving metastasis.

"Malignant change, whether 'sarcomatous' or 'carcinomatous,' in mixed tumors must be rare, and its occurrence is difficult to prove.

"As intervals of 10, 20, and even 30 years may elapse between the operative removal of a mixed tumor and its recurrence, caution should be exercised in declaring any case to be cured."

PROGNOSIS—CARCINOMA

In carcinoma of the parotid gland the prognosis is very bad. Very few patients have been cured, but we believe that extensive operation is the only hope, and may result in some cures. Of 30 cases of proved carcinoma treated by

TON MEMORIAL HOSPITAL CASES

Operation	Encapsulated or not capsule broken	Vessels ligated and damage caused	Nerves damaged	Length of life after last operation	Length of life after first noticed	Recurrence	Radium or X-ray treatment	Remarks Cause of death as on death certificate
Excision, 1915 Local surgeon	?		Right facial paralysis	1 yr.	5 yr.	Yes	16 radium treatments	Cancer of parotid and neck
Excision, 1923 Local surgeon				1 yr.	31 yr.	Yes	Yes, both	Cancer parotid neck and question brain
Biopsy				No operation	58 yr.	Yes	Yes, 18 radium treatments	Cancer parotid
Local surgeon Worcester			Right facial paralysis	3 yr.	5½ yr.	Yes	No	Cancer of face and neck
Biopsy of gland				Only biopsy 3 yr.	6 yr.	Yes	13 radium treatments	Cancer neck; hypostatic pneumonia
Excision, 1912 Boston City Hospital			Partial left facial	1 yr.	1½ yr.	Yes	5 radium and X-ray treatments	Cancer parotid and neck; paralysis of palate, tongue, and vocal cord
Excision, 1922 Local surgeon				1 yr.	1½ yr.	Yes	X-ray treatments	Cancer parotid
Excision, 1919 Local surgeon Excision, 1922 Local surgeon Excision, 1929 Huntington			Lower facial	1 mo.	11 yr.	Yes	5 radium treatments. X-ray series improved facial paralysis	Living. Pathological report, 1929, slow growing adenocarcinoma—? coil gland origin not characteristic of parotid
Excision, 1914 Local surgeon				3 yr.	4 yr.	Yes	X-ray treatment	Recurrent cancer parotid with lung metastasis. Cerebral hæmorrhage. Postoperative shock; lung abscess

operation (with or without radium) at the Massachusetts General and Huntington Memorial Hospitals, there is only 1 now living and apparently free of the disease, an ultimate mortality of 96.7 per cent. All the other cases died of cancer with the exception of 2, 1 of whom (Case 62) had four operations, three of them for recurrences, thirty X-ray treatments (with very little if any benefit), but who finally succumbed to gall stones, at the age of 73 years, 1 year after her last parotid operation. The other patient (Case 79) still living now, was a woman of 67 years, who had had the tumor excised by her own doctor in 1919 and again in 1922, followed by a series of X-ray treatments in 1923, and five radium treatments in 1926, after which the tumor practically disappeared. In December, 1929, however, there was a recurrent nodule, 2 centimeters in diameter, which was excised, and reported to be slow growing adenocarcinoma, question of sebaceous gland origin, not characteristic of parotid. Obviously neither of these patients can be considered cured, as the first one still had the tumor at the time of her death from gall stones, and the other patient has had a recent recurrence. Moreover, the recent pathological report in this latter case casts some doubt on the origin of the tumor. Our one "cured" case (Case 61) is only a 3 year cure, as her operation here was quite recent (1925) and we have been unable to get in touch with her since 1928. Presumably the growth was not very malignant, as the surgeon described it as "encapsulated in its lower portion" but "apparently infiltrating in the upper part." The pathological report, however, was adenocarcinoma.

Local recurrence after removal of parotid cancer is usually very prompt, being a matter

of months rather than years. Secondary operations have been uncommon, only 5 patients having been operated on more than once. One patient (Case 57, Figs. 2 and 3), however, was operated on twelve times between 1909 and 1922, the pathological report every time being carcinoma, and the various operations including excision, cauterization, neck dissection, radium implantation, etc. The last operation was a biopsy of the lung, which proved to be metastatic carcinoma. This patient died of recurrent carcinoma of the parotid with metastases to the lung in 1924.

Metastasis from cancer of the parotid may occur in the lungs, and one case of metastasis in the bones has been reported. We had 2 cases in which lung metastasis occurred; one (Case 56), a woman of 56 years, who had no local recurrence but who died, only 2 years after her operation, of cancer of the lung and cerebral hæmorrhage; the other, already mentioned (Case 57), a woman of 33 years, who had twelve operations, and who died 15 years after her first operation, of cancer of the lung. Another case, with metastatic nodules in the skin of the chest wall, has recently come to our attention.

The length of life after operation has been almost invariably short. Of 14 cancer patients not given radium or X-ray treatment, none lived over 2 years after operation. Six lived between 1 and 2 years. Five died in 6 months or less. Of 10 cancer cases which did receive radium or X-ray treatment in addition to excision, 3 lived over 2 years (2½, 3, and 5 years, respectively). Only one (Case 45) died within 6 months. The patient (Case 57), who was operated upon 12 times, and who also received radium and X-ray treatment, lived 15 years after her first operation for cancer of the parotid. Radium thus seems to be helpful in prolonging life but not in curing the disease.

PROGNOSIS—SARCOMA

Here again in sarcoma the prognosis is bad, though apparently not as bad as in carcinoma. Of 9 patients, 3 lived over 5 years (5, 8, and 9 years, respectively). The patient (Case 69) who lived 5 years had three operations and radium treatments, and died of sarcoma of the parotid. The patient (Case 70) living 8 years is now living, is free of any recurrence, and was seen very recently. She has never had X-ray or radium treatment. The patient (Case 71, the mælanotic sarcoma case previously mentioned) who lived 9 years, died of chronic cardiac disease and pulmonary infarct. She probably had no recurrence and no X-ray or radium treatment, though this is not certain.

Recurrence. Three patients died only a few days after operation of shock or hæmorrhage. (Two of these had had ligation of the common carotid artery.) Of the 6 remaining sarcoma cases, 4 had recurrence, 2 dying of sarcoma in 3 months, the 2 others in 1 year and 5 years, respectively.

Metastasis. There is no record in this series of any distant metastasis from sarcoma of the parotid. These tumors do, however, rapidly infiltrate neighboring structures, the lymphosarcomata metastasizing by the lymphatics and the fibrosarcomata probably by the blood stream.

TUMORS SECONDARILY INVOLVING THE PAROTID GLAND

In the study of this series of cases 7 more came to our notice as invading the parotid gland secondarily. Of these, 4 were carcinoma, 1 mælanotic sarcoma, 1 malignant lymphoma, and 1 malignant tumor of uncertain origin.

The site of the original tumor in the carcinoma cases was different in each case; one originated in the neck, one in the cheek, one in the jaw, and another in the external ear; all resulted fatally in 1 day, 3 years, 8 years, and 17 months, respectively. The patient who died one day after operation had had a Crile clamp placed temporarily on the common carotid artery, and died of shock, never regaining consciousness. The 3 others all died of carcinoma.

The mælanotic sarcoma case was as follows:

A man of 59 years entered the Massachusetts General Hospital in July, 1919, with a hard mass of 4 years' duration, about the size of a walnut, located at the angle of the jaw on the right side. Under ether an encapsulated tumor of the parotid was

Fig. 1. Case 66. Patient aged 72 years had had disease for 30 years. Pathological diagnosis: sarcoma of the parotid gland.

excised. The pathological report by Dr. H. F. Hartwell was mælanotic sarcoma of the parotid.

This case, therefore, appears to be one of the very rare cases of mælanotic sarcoma arising from the parotid gland, although it may have originated in the neck. Unfortunately, we have been unable to trace this patient.

The patient with malignant lymphoma first had symptoms in 1908, a chain of glands appearing in the neck. Biopsy was done in 1912. Excision and neck dissection was done twice in 1913. A neck dissection, excision of the mastoid and the parotid gland, was done in 1915, and the parotid gland was again excised in 1916. In 1921 the death of this patient is recorded at the State House in Boston, the cause of death being "sarcoma of the neck."

The malignant tumor of uncertain origin is the most interesting of all, for after repeated operations on a tumor that clinically seemed hopelessly incurable, and pathologically seemed extremely malignant, the patient, with the common carotid ligated, is

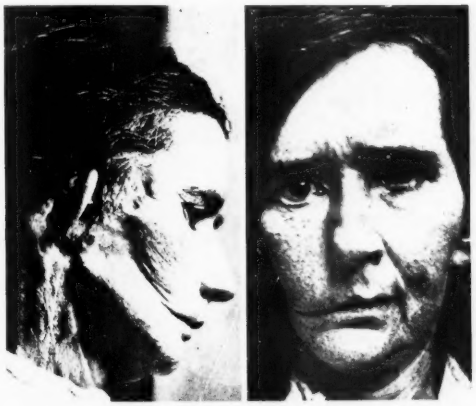

Fig. 2, left. Case 57. Patient aged 46 years, showing scars of face and neck after twelve operations for carcinoma of the parotid.

Fig. 3. Case 57 showing complete right facial paralysis.

still living and well at the age of 72 years! The record is as follows:

First admission. E. L., a man of 41 years, entered the Massachusetts General Hospital in March, 1898, with a history of having noticed a small pimple below the left ear, 14 months previously. It had been cut off once with a horsehair, but had reappeared and enlarged. Physical examination showed a series of large nodular masses on the left side of the neck. An extensive operation was performed, the mass shelled out, and profuse hæmorrhage resulted, necessitating ligation of the common carotid artery. The pathological report was mælanotic sarcoma.

Second admission. The tumor recurred immediately and the patient was readmitted in 2 months (May 30, 1898). Operation was again performed, the "dissection carried down to the sternomastoid as thoroughly as possible, but with manifestly little hope of eradicating the disease." The pathological report was again mælanotic sarcoma.

Third admission. One year later the patient was again admitted, with a recurrence of about 3 months' duration. Operation was done on May 24, 1899, and "the mass was dissected free down to the transverse processes of the vertebræ beneath, and cut off with scissors, some of the growth being left at the bottom of the wound." The pathological report this time was round-cell sarcoma of the neck and adenocarcinoma of the parotid.

Fourth admission. In September, 1900, the patient was again admitted and the growth explored, but not removed, as the surgeon thought the tissue looked like normal parotid gland.

Fifth admission. In January, 1902, the patient re-entered the hospital with a tumor the size of a pullet's egg in the parotid region. An extensive

operation was performed, a portion of the jugular vein, which was involved in the disease, being ligated and removed. The pathological report was large round-cell sarcoma.

Follow-up. This patient was seen by us in April, 1927, and was found to be in excellent health, with no evidence of recurrence. There was complete left facial paralysis. In September, 1929, we heard that this patient was still living, 27 years after his last operation!

Pathology. A review of the microscopic slides in this case has shown a tumor composed of cells which appeared to be extremely malignant, and, although no definite diagnosis could be made, it was probably not mælanotic.

The value of repeated and extensive operations in apparently hopeless malignant disease is well shown in this case.

SUMMARY AND CONCLUSIONS

We have reported on a large series of parotid tumors, with complete records as to pathology and end-results in 80 cases. The conclusions to be drawn are as follows:

1. Benign tumors are more common than malignant tumors in the ratio of about four to three.

2. Carcinoma is about twice as common as sarcoma.

3. Cysts, mælanotic sarcomata, and adenomata are extremely rare.

4. Mixed tumors are essentially benign, but recur locally with great frequency. They rarely become malignant.

5. Malignant parotid tumors are very difficult to cure. Once the diagnosis is established, we advise early radical operation, including ligation of the external carotid artery and severing of the facial nerve whenever necessary.

6. Patients with mixed tumors live indefinitely. Patients with malignant disease rarely live over 2 years after operation.

7. Radium and X-ray are useful in the treatment of malignant parotid tumors, but only as palliative procedures. In the treatment of benign parotid tumors, radiation therapy is of benefit in some cases, but we believe excision is the treatment of choice.

8. Carcinoma, sarcoma, and malignant lymphoma may invade the parotid gland secondarily. Such cases usually end fatally, but one brilliant cure reported here justifies many extensive operations, and emphasizes the importance of not giving up in our struggle against malignant disease.

Since the completion of this paper another case has come to our attention, interesting because of the youth of the patient, the high malignancy of the tumor, the metastases in the chest wall, and the rapid, fatal termination.

A. LeF. (E. S. 288980), a boy of 15 years, entered the Massachusetts General Hospital on February 1, 1928, complaining of a tumor on the right side of the face, of 5 months' duration. There had been no pain. Examination showed a "firm, elastic, smooth, non-tender egg-sized swelling, lying over the right mandible and extending from the angle of the jaw forward to the submaxillary region. Above it extends on to the cheek and below it extends in front beneath the ramus of the mandible. It is quite freely movable in its superior part but is apparently fixed to the bone inferiorly and is more firm and indurated here than above. At its dependent portion there is a fresh scar about 2 centimeters long from a biopsy done 2 weeks ago." Operation was performed within a few days, "the tumor tissue was resected entirely, regardless of structures." Convalescence after operation was good, and the patient was discharged from the hospital in about 2 weeks, after completing a series of X-ray treatments.

Pathological report showed "a tumor the size of a tennis ball, aggressive and rapidly growing. An adjoining lymph node was negative for metastasis. Carcinoma."

Follow-up. The patient was followed during March and April in the tumor clinic. On April 6, five or six skin nodules were noted on the chest wall. A biopsy was done which showed metastatic carcinoma, and further X-ray treatment was given and caused some of these nodules to disappear almost entirely. In spite of X-ray treatment, however, a rapid recurrence of the growth took place at the original site, further metastatic nodules appeared on the chest wall, and the patient died on May 14, 1928, only 3 months after operation, and only 8 months after the tumor was first noticed.

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INTRATHORACIC NEW GROWTHS

RESULTS OF SURGICAL TREATMENT IN TWENTY-FOUR CASES[1]

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THE seeming increase in the incidence of intrathoracic tumors undoubtedly is due to the marked advancement that has been made in the methods of thoracic diagnosis and not to an increase in the occurrence of these new growths. The most significant advancement in early diagnosis has been made since the advent of the roentgen-ray. Recognition of these tumors before the patient is *in extremis* has led to the application of various types of treatment for relief of symptoms. Roentgen-ray and radium are the more commonly used agents in conservative treatment. In some of the malignant growths, such as sarcoma, malignant lymphoma, and endothelioma, there has been improvement or delay in the progress of the disease. In adenocarcinoma there has been little if any improvement. The lack of response to treatment of many of these tumors, and knowledge of the frequency of occurrence of benign tumors which do not respond to conservative treatment, and which may undergo malignant degeneration, has stimulated surgical intervention, with the purpose of removing the growth completely.

In 1929, I reported 17 cases of intrathoracic tumor in which the growth had been removed by transpleural operation in the previous 4 years. I am here giving complete reports of the 7 cases in which I have operated in the last year. In 5 of these cases the tumors were primary in the thorax and mediastinum; in 2 cases they were metastatic carcinomata and were of unusual interest from a diagnostic standpoint because they could not be distinguished from primary thoracic tumors before operation. I am also giving a brief summary of the symptoms, methods of diagnosis, surgical treatment, and results to the present time of the entire series of twenty-four cases.

SYMPTOMS

The symptoms and signs of intrathoracic growths depend on the size and situation of the tumor in the thorax. There are no characteristic symptoms by which early malignant lesions and early benign lesions can be distinguished. Pain is the most common symptom and usually is the chief complaint for which the patient seeks relief. The pain is usually more severe in malignant lesions than in benign lesions. This is particularly significant when the relative size of the tumors and their situation are considered. A benign tumor may fill from a fourth to practically the entire hemithorax without causing much pain or discomfort except on exertion, and most of the distress is caused then by dyspnœa from mechanical interference with breathing. A malignant tumor of much smaller size, in the same situation, will cause most excruciating pain, often most marked at night, or when pressure is exerted on the thorax.

Horner's syndrome was present in 3 cases in which a malignant tumor was found at the apex of the thoracic cavity. This, I believe, is due to infiltration and destruction with malignant cells of the inferior cervical ganglion, rather than to pressure from the size of

[1]Read before the Philadelphia County Medical Society, Philadelphia, Pennsylvania, March 12, 1930.

Fig. 1. Roentgenogram made on admission. There is marked density over entire left side of thorax to the level of first rib, probably due to tumor with fluid. The heart is markedly displaced to the right. Case 1.

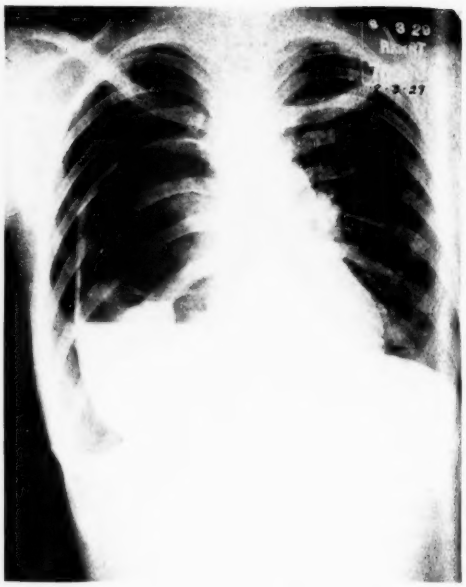


Fig. 2. Roentgenogram made after removal of 3,000 cubic centimeters of fluid and introduction of 2,250 cubic centimeters of air into the left pleural space. The shadow is of a large, intrathoracic, cystic tumor, with fluid in lower fourth of the cyst. Irregular shadows indicate solid portion of the tumor. The left lung is completely collapsed. There is partial pneumothorax at the apex. Case 1.

the tumor; I have removed much larger benign tumors from the same site and Horner's syndrome was not present.

Most intrathoracic tumors are potentially malignant. Any tumor which has been dormant for a long time, and which has begun to grow rapidly, and to cause increase in pain, should be considered as probably malignant. This is particularly true of anterior mediastinal tumors of which teratoma or dermoids are the most common. These tumors usually cause more symptoms because of their confined situation and their structure. They contain a considerable number of glandular and secreting cells, and are usually cystic. The symptoms often simulate pleurisy because of the inflammatory reaction in the tumor, which fuses it to the parietal and visceral pleura and all surrounding structures.

Dyspnœa is more marked in cases of anterior mediastinal tumors than in tumors of the posterior or lateral portions of the thorax.

Cough is most marked in cases of tumor of the anterior mediastinum and in cases of malignant tumor involving the lung. In cases of malignant tumor, it is usually of a dry, non-productive type or occasionally the sputum may be tinged with blood. In dermoid tumors there may be expectoration of hair, which is pathognomonic.

Vascular changes are not common and usually are seen only in lesions of the upper part of the thorax and of the anterior mediastinum.

METHODS OF DIAGNOSIS

The general examination is of greatest importance in determining the condition of the patient and always is the deciding factor in determining the type of treatment to be instituted. Examination of the thorax is of value in determining the situation of the tumor and the amount of impairment to respiration.

The roentgen-ray is the most important single method of diagnosing the presence of an intrathoracic tumor and of distinguishing be

tween a malignant and a benign lesion. The roentgenogram made from the anterior aspect is of value in determining the presence of an intrathoracic tumor and its vertical and lateral positions. Roentgenograms made from the lateral aspect determine the anteroposterior and vertical position of the tumor and its relation to the thoracic wall. Roentgenograms made obliquely are of value in determining the position of the tumor and its relation to the structures in the mediastinum, particularly the heart and aorta. Stereoscopic roentgenograms add visualization of depth to the determination of the lateral and vertical positions and give more accurate knowledge as to the relation of the tumor to the normal structures within the thorax. Roentgenographic studies of the relation of the tumor to the lung are greatly aided by preliminary artificial pneumothorax. This is of greatest value in distinguishing intrapulmonary and extrapulmonary lesions or whether the lung is adherent to an extrapulmonary lesion. If the lesion is intrapulmonary, the surrounding pulmonary tissue will collapse over the tumor. However, I have had 2 cases in which the tumor was in the anterior mediastinum, but the roentgenogram indicated that there was an intrinsic tumor of the lung. At operation the tumors were found to be extrinsic and the lung was so adherent that the pulmonary tissue collapsed over the growth.

Fluoroscopic examination is of great value in determining the site of the tumor and its relation to the normal structures within the thorax. It is particularly valuable in differentiating new-growths and expansile aneurisms of the aorta. In tumors of the upper mediastinum, it aids in differentiating primary intrathoracic tumors and substernal goiters, which elevate on swallowing.

Bronchoscopic examination is of great aid in differential diagnosis, particularly in ruling out primary intrabronchial disease, and malignancy. In some cases an extrinsic tumor may be indicated by narrowing of the bronchus.

Injection of the bronchial tree with iodized poppy seed oil, 40 per cent, may be of value in distinguishing between intrapulmonary and extrapulmonary lesions. Thoracoscopic examination may aid in selected cases in determining the type and position of the tumor but usually I prefer to do exploratory thoracotomy.

Fig. 3. Lateral view, made following removal of 3,000 cubic centimeters of fluid and introduction of 2,250 cubic centimeters of air into the left pleural space. The tumor occupies most of the left thoracic cavity and apparently originated anteriorly. The level of the intracystic fluid is increasing at the base of tumor, showing a saccular type of tumor. Case 1.

The chief problems associated with surgical removal of intrathoracic tumors are concerned with the danger of pulmonary collapse, with mediastinal flutter resulting from open pneumothorax, and the difficulty of access through the bony encasement of the thorax. The first of these hazards has been greatly diminished by the use of differential air pressure during the operation. The second is entirely a technical problem and the technique of methods of approach continually are being improved and perfected.

The surgical indications depend entirely on the observations in each case, and there is no type of surgery in which the ultimate result depends so much on the strictest attention to detail in each step of the treatment.

I believe that the operative risk is decreased by establishment of preliminary artificial pneumothorax for a few days before operation

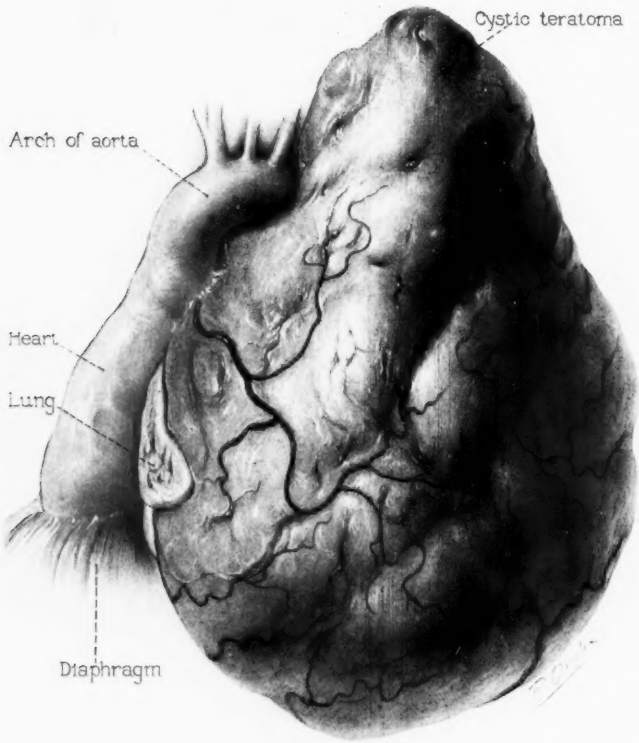


Fig. 4. Appearance of the tumor at the time of operation. The anterior origin of the tumor, with its attachment to the upper part of the pericardium and base of the great vessels, and also the projection extending into the arch of the aorta, are represented. The large cystic mass completely filled the left half of the thorax, with complete collapse of the left lung posteriorly. Case 1.

to permit the patient to become accustomed to unilateral partial collapse and decreased vital capacity of the lung. In this series of 24 cases, preliminary artificial pneumothorax was established in 15 cases. During the pre-operative period the patient should take at least 3,000 cubic centimeters of fluid daily.

I prefer to use intratracheal anæsthesia under positive pressure. I have operated with intrapharyngeal anæsthesia, with the closed mask, and without positive pressure of the anæsthetic, without harmful results. It is probable that intrapharyngeal anæsthesia would be satisfactory in most cases in which one pleural cavity is opened, but it is never possible to determine before operation what emergency may arise or when the opposite pleural cavity may be opened unavoidably. I believe that anæsthesia by intratracheal insufflation, and administered with apparatus for positive pressure, is the safest method in most cases; this method was used in 17 cases of this series. The anæsthetic was ethylene and ether in practically all cases. Many of these operations are long and tedious, and it is important to ventilate and re-establish circulation by fully expanding the lung every 3 to 5 minutes during the operation. The amount of pressure used is gauged by a water manometer on the positive-pressure apparatus. The lung is fully inflated at the completion of the operation. A suction pump

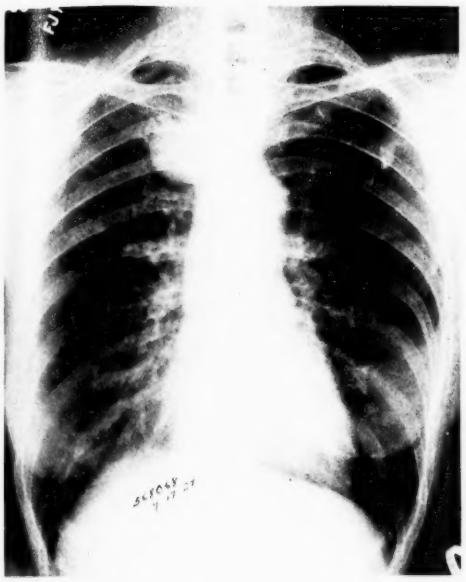


Fig. 5. Roentgenogram taken on admission. The small, circumscribed shadow is in the right side of the posterior mediastinum, at the level of the fifth and sixth ribs, posteriorly. It was interpreted as probably indicating a benign tumor. Case 2.

applied to the intratracheal catheter, during its withdrawal, to remove any mucus which may have accumulated in the trachea.

The surgical approach through the thoracic bony cage depends on the site and size of the tumor. If the tumor is attached to any part of the bony thoracic wall, or if it is an outgrowth of the bony wall, laterally or anteriorly, I prefer to make the incision at the site of the tumor. In 8 cases of this series, anterior or lateral thoracotomy was done over the site of the tumor. If the tumor is in the anterior or posterior mediastinum, or in the lung, I prefer to do posterolateral thoracotomy, usually partially resecting a rib, and opening the pleura through the posterior periosteum. The vertical position of the incision, and the rib to be resected, depends on the site of the tumor. In 16 cases, posterior thoracotomy or mediastinotomy was performed to remove the tumor from the anterior or posterior mediastinum. In 18 cases, the tumor was removed in one stage, by a transpleural opera-

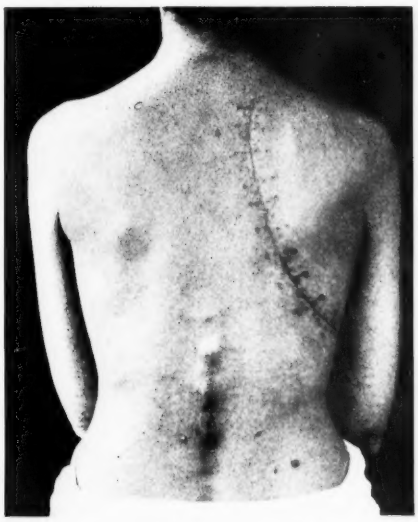


Fig. 6. Photograph taken at the time of re-examination, 2½ months after operation. The wound is entirely healed. There is no deformity or limitation of function of the arm. Case 2.

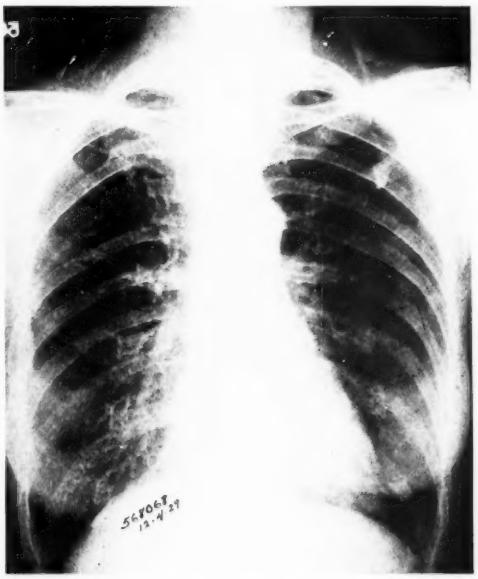


Fig. 7. Roentgenogram taken at re-examination, 2½ months after operation. The lungs appear normal. The evidence of partial resection of the fifth rib, and of a section of the fourth rib is seen. The right lung is fully expanded. Case 2.

Fig. 8. Roentgenogram of the thorax (lateral view) on admission. There is a large intrathoracic tumor, filling the upper two-thirds of right thoracic cavity and resting on the spinal column, posteriorly. A large portion has protruded through the anterior thoracic wall, with destruction of the second, third, and fourth ribs, anteriorly. Case 3.

tion. This type of operation, I believe, is the most satisfactory and should always be attempted if at all feasible. In one case the tumor was completely removed by extrapleural operation. This type of operation is rarely possible, because the pleura is so adherent to the tumor that the pleural cavity is ultimately opened more or less extensively before the tumor is entirely enucleated, with the associated danger of open pneumothorax. The greatest disadvantage of this procedure is the delay in healing, and the extensive pleural effusion which usually follows the operation. This is due to the trauma resulting from the extensive separation of the pleura from the thoracic wall. In one case the tumor was removed by a transpleural operation in two stages. The operation in two stages was planned because of the extensive procedure necessary. The first stage was done to separate the tumor from the surrounding structures and to form adhesions between the

TABLE I.—CASES OF INTRATHORACIC TUMOR IN WHICH OPERATION WAS PERFORMED BETWEEN MARCH, 1925, AND MARCH, 1930

	Malignant	Benign
Operation*		
Transpleural complete removal in one stage	7	11
Extrapleural complete removal in one stage	..	1
Transpleural complete removal in two stages	1	
Transpleural partial removal in one stage	4	
Deaths		
Operative mortality	1	1
Subsequent mortality	7	

*Preliminary artificial pneumothorax was done in 15 cases.

TABLE II.—CASES OF MALIGNANT INTRATHORACIC TUMOR IN WHICH OPERATION WAS PERFORMED BETWEEN MARCH, 1925, AND MARCH, 1930

Type of tumor, each one case	Extent of removal	Length of life following operation, months: Living	Dead
Osteofibrosarcoma, graded 2	Complete	57	...
Fibromyxosarcoma, graded 1	Complete	...	27
Fibrosarcoma, graded 1	Complete	6	...
Fibro-osteochondrosarcoma, graded 3	Complete	...	5
Sarcoma, graded 3	Complete	...	4.5
Osteogenic sarcoma, graded 3	Partial	...	1.5
Malignant endothelioma, graded 4	Complete	...	25
Malignant endothelioma, graded 4	Complete	...	2
Adenocarcinoma, graded 3	Partial	...	3.5
Adenocarcinoma, graded 1	Partial	1.5	...
Adenocarcinoma, graded 4	Partial	1	...
Squamous cell epithelioma, graded 4 (dermoid)	Complete	...	7 days*
Total number of cases	12		

*Operative death; cerebral embolism.

visceral and parietal pleura above the tumor, walling off the remaining pleural cavity. The result of this procedure was unsatisfactory, inasmuch as an extensive pleural effusion formed and this delayed and increased the hazard of the second operation rather than decreased the risk as had been planned. I believe that, whenever possible, the operation should be done in one stage rather than in two stages. In 4 cases, in all of which there were extensive malignant conditions, the tumors were only partially removed at operation because of the inoperability of the condition. There were 2 operative deaths in the entire series of 24 operations, one on the second day and one on the seventh day (Table I).

The blood pressure is taken every 5 minutes during the operation. When there has been a fall of 10 millimeters of mercury in the pulse pressure, physiological solution of sodium chloride or glucose are given intravenously. If the pulse pressure drops 20 to 30 millimeters of mercury, a blood transfusion is given.

Postoperative care is very important. Maintenance of body heat is essential both on the operating table and after operation. The most significant immediate complication is dyspnœa with cyanosis. If this occurs, the patient is placed immediately in the oxygen chamber. This often proves to be a life-saving procedure, for it tides the patient over the critical period of decreased vital capacity of the lungs. The oxygen chamber was used in 11 cases of this series. Later complications are pleural effusion and empyema. In practically all cases pleural effusion develops, but in about a third of the cases aspiration is not required. In about a third of the cases it will disappear after one aspiration, and in the remaining third it will require repeated aspirations. The frequency and persistence of the pleural effusion depend on the type of tumor and the amount of trauma to the pleura. In the cases with teratoma, pleural effusion is most likely to develop and may result in empyema. Empyema complicated the convalescence in 5 cases of this series, in all of which drainage was by the closed method. In one case subsequent open operation was required. All patients made a complete recovery.

Table II gives the type and grade of malignancy, the operative procedure and results to March 1, 1930, in all cases in which malignant disease was present. In 3 of the cases the clinical history indicated the presence of a tumor for many years, with recent increase in growth and symptoms. This suggested a primary benign tumor which had undergone malignant change. In the first of these cases, the tumor was a fibrosarcoma. The symptoms extended over a period of 24 years; for 21 years the symptoms had been mild and the condition had been treated as neuritis. At a time 3 years previous to admission to the clinic, the pain had been of the same nature as before but had become progressively worse; morphine had been required for relief and

Fig. 9. Photograph taken on admission showing the large protrusion on the anterior thoracic wall. Case 3.

there were general symptoms of gradual loss of weight and strength. It is only reasonable to conclude that this tumor primarily was benign. This patient lived 27 months after transpleural removal of the tumor in one stage through an anterior incision in which the clavicle was cut. Death was due to recurrence. In the second case of the 3, the clinical history indicated the presence of a tumor for 6 years. At the patient's first visit to the clinic, 3 years before the time of which I am speaking, she had been advised to have an operation, but had declined. Two months previous to operation, the pain in the thorax became much more marked, was rapidly progressive, and radiated to the back. She had noticed loss of weight for 6 months. At the time of operation a fibromyxo-osteochondrosarcoma, graded 4, was removed. The patient died from recurrence 5 months after operation. It is possible that this was primarily a benign tumor which had undergone malignant change. This case (Case 4) is being reported more in detail in this paper. In the third case of the 3 a squamous cell epithelioma, which undoubtedly was a degenerated dermoid cyst, was

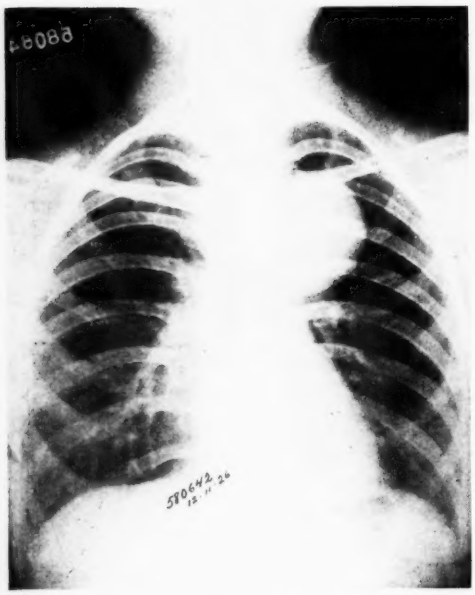


Fig. 10. Roentgenogram taken at the time of the patient's first visit. There is a large, circumscribed tumor in the upper part of the left posterior portion of the thorax, and extending from the fourth to sixth ribs, posteriorly. Case 4.

presented. Mild symptoms had been present for 4 years and had become severe in the 3 months previous to admission. The tumor was in the anterior mediastinum and was removed by transpleural mediastinotomy in one stage. Examination of the tumor disclosed the typical structure of a dermoid cyst, and the malignant tissue was situated in one region of the tumor which indicated malignant change in a benign tumor. This case was the only operative death in the malignant group, and the patient died, on the seventh day, of cerebral embolism.

In 8 cases the tumor was completely removed; 4 of the patients lived less than 6 months, and one patient is now living after 6 months. One patient lived 25 months; in this case it was necessary to resect the greater portion of the lower left part of the thoracic wall and a portion of the diaphragm, and to repair the defect with the remaining portion of the diaphragm after phrenicotomy. The tumor was an endothelioma of high grade and was recurrent at the time of operation. The patient was relieved of symptoms for 22 months, when he began to fail rapidly and died from recurrence. One patient who had sarcoma lived 57 months after operation with no evidence of recurrence, and one patient lived 27 months after operation with relief of symptoms for more than 2 years and then died of recurrence. The results in these cases of malignant tumors do not seem to have any direct relationship to the type or degree of the malignant growth except in those cases in which adenocarcinoma of the lung is present; in these the prognosis is poor. The results in the other groups, although not satisfactory, are at least encouraging, and emphasize the importance of operation before the disease has advanced beyond the possible limits of surgical removal or before malignant change has occurred.

In 4 cases the tumor was only partially removed because of inoperability due to extensive infiltration into the surrounding structures. In one case there was apparently a

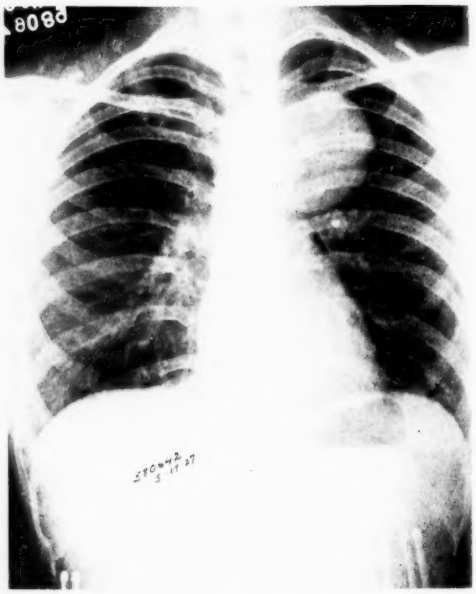


Fig. 11. Roentgenogram taken at the time of the patient's second visit, 5 months after the roentgenogram shown in Figure 10 was made. No increase in the size of the tumor is seen. Case 4.

TABLE III.—CASES OF BENIGN INTRATHORACIC TUMOR IN WHICH OPERATION WAS DONE BETWEEN MARCH, 1925, AND MARCH, 1930

	Length of life since operation, months
Neurofibroma	41
Neurofibroma	24
Neurofibroma	11
Neurofibroma	5
Cellular fibroma	22
Cellular fibroma	22
Teratoma	17
Teratoma	16
Teratoma (dermoid)	13
Teratoma (dermoid)	7
Osteochondroma	24
Fibromyxochondroma*	
Total number of cases	12

*Operative death; died 2 days after operation from cardiac failure and shock.

sarcoma originating in the thoracic wall which had invaded the mediastinum. In the 3 others the tumors were adenocarcinomata; 2 were primary in the lung and 1 metastatic from a carcinoma of the thyroid gland. As would be expected, the operation had no influence on the course of the disease in this latter group. All of these patients were given treatment by roentgen-ray after operation, without benefit.

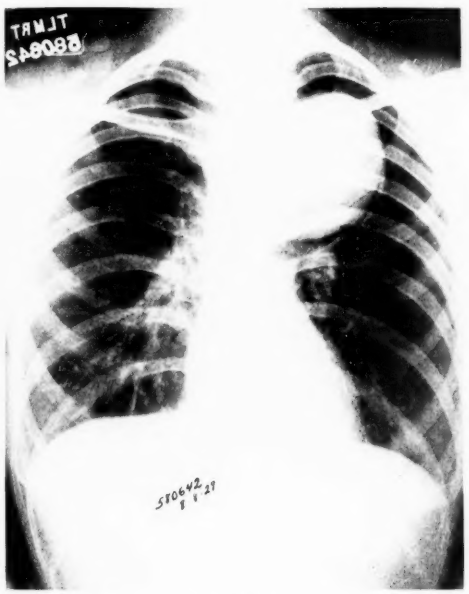


Fig. 12. Roentgenogram taken 2 years and 5 months following the first visit. Marked increase in the size of the tumor has taken place. It is approximately a third larger than it was at the previous visit. The tumor extends from the third to the sixth interspace posteriorly. Case 4.

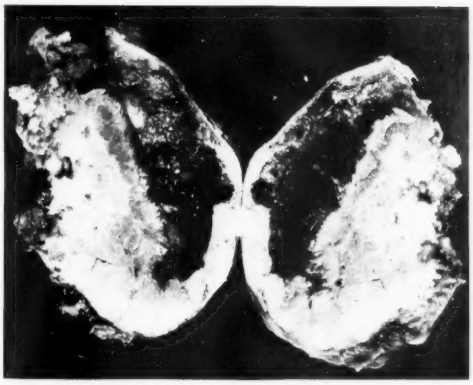


Fig. 13. Photograph of the tumor, a hæmorrhagic degenerating fibromyxo-osteochondrosarcoma associated with a hæmangio-endothelioma, weighing 220 grams. Case 4.

In Table III are given the types of tumors and results of operation in all cases of benign tumor.

In 12 cases of the entire series of 24 cases, the tumor was benign. In all of these cases the tumor was removed by operation in one stage. In 11 cases the operation was transpleural, and in 1 case it was extrapleural. There was 1 operative death on the second day, from cardiac failure and shock. This case will be reported in detail in this paper. Eleven patients are living from 5 to 41 months after operation; all have been completely relieved of symptoms and there has been little, if any, deformity or impairment of pulmonary function. Complete cure is to be expected in all of these 11 cases.

Four of these 12 cases were examples of neurofibroma in all of which the tumors were in the posterior mediastinum. I am reporting 1 case (Case 2) of these 4 in detail in this paper. In 2 cases, the tumors were cellular fibromata; one was in the upper and one in the lower part of the thorax. Both of these were very large tumors. One involved the upper half of the thorax, was cystic, and had been treated as a tuberculous pleural effusion. In the other case the tumor involved the posterior, lower third of the thorax and was accompanied by

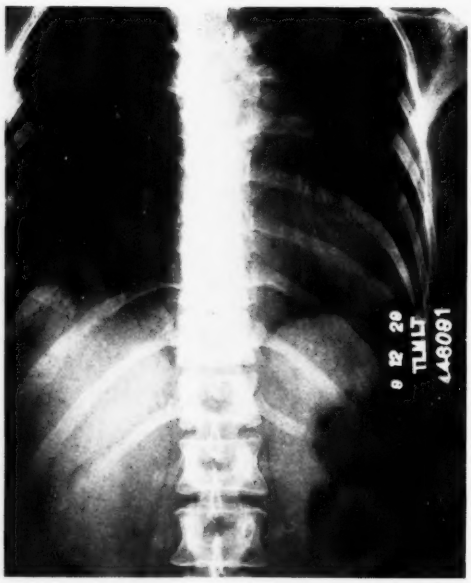


Fig. 14. Roentgenogram on admission, at time of first visit of patient. Destruction of half of the fifth, sixth, and seventh left thoracic vertebræ is seen. Case 5.

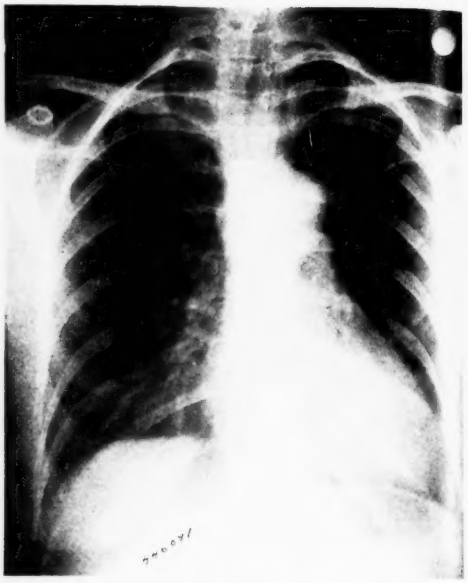


Fig. 15. Roentgenogram following injection of lipiodol into the spinal canal, with partial obstruction at the site of the tumor. Case 5.

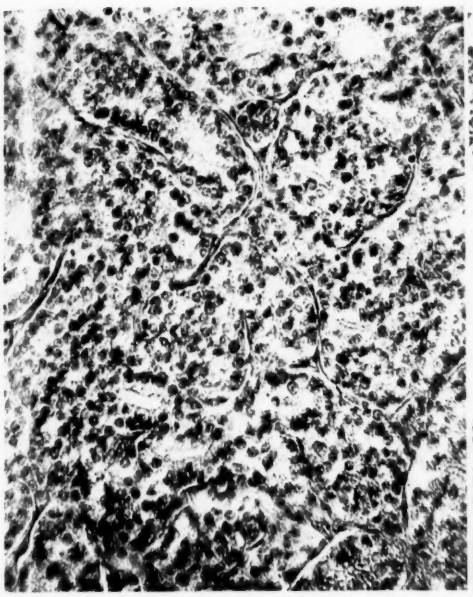
a bloody pleural effusion which was thought to be due to malignancy. This is the only case in which I have seen a benign tumor associated with bloody pleural effusion.

There were 4 cases of teratoma. In 2 the tumors were of definite dermoid type, one of which involved the entire thorax. The latter case (Case 1) is reported more in detail in this paper. In 1 case the tumor contained thymic tissue, and in the other the growth consisted almost entirely of cartilage, bronchi, and embryonic structures resembling pulmonary tissue.

All of these tumors were in the anterior mediastinum, were fixed, and lay over the great vessels and upper portion of the pericardium, with a projection extending under the arch of the aorta. They were extremely adherent to all of the surrounding structures. Three of the tumors, although they extended more into one side of the thorax than the other, were adherent to the pleura of both pleural cavities. In one instance, both pleural cavities were opened in the course of removal of the tumors. I believe that all intrathoracic tumors should be considered potentially malignant. The teratomata are more likely to undergo malignant degeneration than any other type of benign tumors.

There were 2 cases of chondroma, in 1 of which occurred the only operative death in the entire group of benign tumors. This latter case (Case 3) is reported later in this paper. The tumor was huge, practically filling the entire thorax, and a large mass protruded through the thoracic wall. Death was due to the extensive type of operation which was necessary, in a patient who was *in extremis*. This case exemplifies the importance of early operation in all cases of benign tumor before serious injury from pressure has been done to surrounding structures. These injuries may cause death.

These cases of benign tumor are the most gratifying from a surgical standpoint, for the risk is not great if the tumors are removed before they have become so large as to cause pressure on the surrounding structures. If the patient survives the operation, complete cure is obtained. The frequency with which



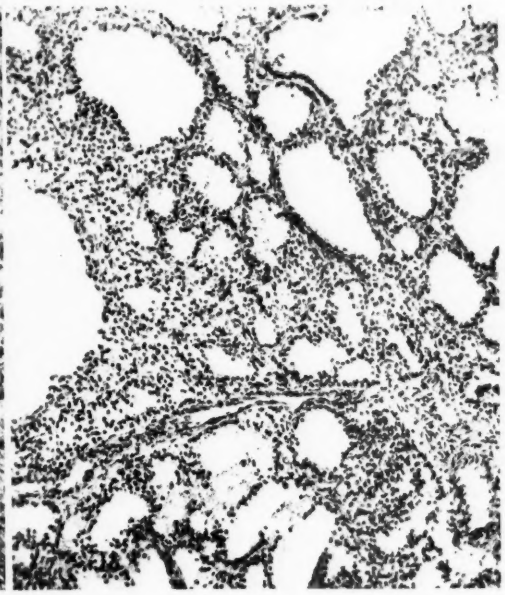


Fig. 16, left. Tissue from the thyroid gland. Adenocarcinoma, graded 2, in a colloid and fetal thyroid gland. Case 5.

Fig. 17. Tissue from the tumor, adenocarcinoma, graded 2, of the thyroid type. Differentiation into columnar epithelium has taken place to a large extent. The specimen bears a close resemblance to an exophthalmic goiter. Case 5.

these benign tumors become malignant is the most significant indication for their early surgical removal. Because of the difficulty in establishing a definite clinical diagnosis, I believe that exploration should be done in all cases unless the clinical evidence is that a hopeless inoperable condition exists.

REPORT OF CASES

CASE 1. A woman, aged 18 years, consulted the clinic July 22, 1929, complaining of pain in the left side of the thorax of 6 months' duration. There was nothing in her history or the family history referable to her present complaint. She had had good health until 2 weeks after childbirth, 6 months before she entered the clinic, when a sudden attack of severe pain had developed in the left side of the thorax and beneath the sternum; this had been associated with dyspnœa. She had not had fever and the condition had been diagnosed as pleurisy of the left side. The pain had been more or less constant since its onset, with several exacerbations of severe pain associated with dyspnœa. There had been a constant sensation of pressure beneath the sternum, with pain radiating to the left side of the thorax, associated with a dry, non-productive cough. This cough was most noticeable on exertion, and she had noted a slight tinge of blood in the sputum when she had a cold. The immediate reason for the patient coming to the clinic was pain in the right lower quadrant of the abdomen which had been diagnosed as due to acute appendicitis. She had had an indefinite pain in the right lower quadrant for the last 2 years.

General examination revealed that the patient had lost 10 pounds in weight in the last 6 months. She appeared pale, fairly well nourished, and had a hectic flush. The systolic blood pressure was 135 and the diastolic 90, measured in millimeters of mercury. The pulse rate was 124 and the temperature, 99.4 degrees F. Percussion disclosed dullness to flatness throughout almost the entire left side of the thorax with some hyperresonance at the apex of the left lung. Auscultation revealed almost complete absence of breath sounds, and some râles scattered throughout the left side of the thorax. The heart was markedly displaced to the right and heart sounds were almost entirely absent from the left side of the thorax. The liver extended about 7.5 centimeters below the right costal margin. There was also a large palpable node in the left axilla, probably inflammatory. Roentgenological examination on admission showed markedly increased density over the entire left side of the thorax, to the level of the first rib; probably this was due to a tumor with fluid. The heart was markedly displaced

Fig. 18. Roentgenogram made on admission (lateral view). The large intrathoracic and extrathoracic tumor is seen in the middle portion of the thorax. The intrathoracic portion extends half way to the spinal column. Case 6.

to the right. A clinical diagnosis was made of a large tumor of the left side of the thorax, pleural effusion, pulmonary collapse, and displacement of the heart to the right (Fig. 1).

Diagnostic aspiration of the left thoracic cavity was done July 27, and about 1,500 cubic centimeters of brown, turbid fluid, containing erythrocytes and crystals of cholesterol, was removed. Roentgenological examination following this procedure showed a large, left intrathoracic tumor, partial pulmonary collapse, and moderate displacement of the heart to the right. July 31, pleurocentesis and artificial pneumothorax were performed on the left side with removal of 1,250 cubic centimeters of brownish fluid and replacement of 1,250 cubic centimeters of air. August 3, pleurocentesis and artificial pneumothorax again were performed on the left side; 250 cubic centimeters of brownish fluid was removed and 1,000 cubic centimeters of air was inserted. Roentgenological examination after the removal of 3,000 cubic centimeters of fluid from the cyst and insertion of 2,250 cubic centimeters of air into the left thoracic cavity, disclosed a large cystic tumor almost completely filling the left thoracic cavity, with the level of intracystic fluid at the lower third of the tumor. The walls of the tumor were definitely outlined. The lung was completely collapsed posterior to the tumor. There was a small amount of fluid in the cardiophrenic angle of the thoracic cavity. The lateral view, taken 9 days later, revealed the saccular tumor occupying most of the left thoracic cavity and apparently originating in the anterior mediastinum; the level of the intracystic fluid had risen to about the middle of the tumor. A diagnosis was made of left intrathoracic cystic teratoma filling the entire left thoracic cavity, with complete collapse of the left lung (Figs. 2 and 3).

August 18, under intratracheal ethylene anæsthesia, left posterior thoracotomy was performed with removal of the entire seventh rib and sections of the fifth, sixth, and eight ribs. On exposure of the left thoracic cavity, a huge semicystic tumor was seen filling almost the entire left side of the thorax. The tumor was 30 by 20 by 18 centimeters. The upper portion of the wall of the cyst was thin and the lower portion very thick. One large projection, extending under the arch of the aorta, was adherent to the arch of the aorta and pericardium. These adhesions were firm and had to be dissected free with a knife. The tumor was ruptured during its removal. It contained about 2,000 cubic centimeters of clotted blood and fluid containing particles of hair. The entire wall of the cyst was removed with the exception of a few fragments extending under the arch of the aorta. The lung had been completely collapsed, apparently for a long time, and was adherent to the anterior wall of the thorax and to the tumor. These adhesions were separated, and the lung was allowed to drop back into its normal position. The thoracic cavity was washed out with physiological solution of sodium chloride. The lung was reinflated as soon as the tumor was removed and was kept inflated until the wound was closed. The thoracic cavity was drained by intracostal closed drainage through the seventh interspace. The lung was in a thoroughly inflated condition at the completion of the operation. A transfusion of 500 cubic centimeters of blood was given while the patient was on the operating table. The thoracic cavity was drained with a No. 18 French catheter. Pathological study of the tumor revealed a cystic teratoma containing fluid, clotted blood, and sebaceous material; the wall of the cyst contained hair, bone, fibrous connective tissue, muscle, mucus secreting glands, and sebaceous glands (Fig. 4).

The patient's immediate convalescence was stormy; her pulse rate was 160 and respirations varied from 30 to 40; her temperature was 102 degrees F. The first day following operation she was given a second transfusion and placed in the oxygen chamber where her pulse rate dropped to 120, her respirations to 24, and her temperature to 100 degrees F. Her condition remained about the same but with gradual improvement. On the eleventh day a second tube was placed in the ninth interspace for better drainage of the thoracic cavity. Following this, her temperature dropped to normal and her pulse rate to 100. From this time on, her condition gradually improved. On the fourteenth day the fluid became purulent, and the drainage tube was irrigated with Dakin's solution. The empyema cavity became gradually re

duced in size, and there has been gradual re-expansion of the lung to practically complete volume. There has also been marked improvement in the patient's general condition and she has gained about 25 pounds since the operation. She is completely relieved of symptoms of which she complained previous to operation and has no subjective symptoms at present.

This case is of particular interest because of the size and type of tumor and the difficulties encountered in making a definite clinical diagnosis. It is the largest intrathoracic tumor which I have removed. It almost completely filled the left thoracic cavity. Artificial pneumothorax is of great aid in determining the situation of the tumor, and in this case it showed the lung to be entirely collapsed posterior to the tumor and the tumor to be originating in the anterior mediastinum. The preliminary aspirations revealed that the tumor was cystic and the lateral roentgenogram showed the tumor to originate in the anterior mediastinum. This is the fifth teratoma which I have removed. In 4 of these cases, the tumor had originated in practically the same situation in the anterior mediastinum, firmly attached to the pericardium, to the great vessels, and to the arch of the aorta and pulmonary artery with an adherent projection extending beneath the arch of the aorta into the lower cervical region. This tumor had become so large that it had extended laterally into the left side of the thorax, almost completely filling the thoracic cavity and compressing the lung posteriorly. The greatest technical difficulty was in removing the tumor from structures in the anterior mediastinum, and from the lung, without causing serious injury to them. Because of the firm adhesions, it was impossible to remove the tumor intact. I believe that in these cases drainage should always be established, for in a high percentage of cases empyema develops as it did in this case. The operative procedure was complicated by collapse of the lung and by the fact that it was necessary to dissect the portion of the cyst from the pericardium which was causing serious cardiac embarrassment. It was impossible to reinflate the lung every 3 to 5 minutes, as we usually do in these cases, because of the compression of the lung by the tumor. It is always advisable to give some type of intravenous treatment following an operation of this magnitude, either physiological solution of sodium chloride or blood. The administration of oxygen is of great value in the immediate convalescence.

Fig. 19. Photograph of patient on admission. A large tumor of the right anterior portion of the thoracic wall is seen beneath the scar of the previous radical amputation of the breast. Case 6.

CASE 2. A woman, aged 53 years, consulted the clinic July 15, 1929, complaining of exhaustion. She had had good health until pneumonia of the left side had developed 4 years before, at which time she had been in bed for 2 weeks. She had felt fairly well thereafter until 1½ years before she came to the clinic, when influenza had developed. She had been more than a month regaining her strength. During this time, severe, sharp pains "in both lungs" had appeared on deep breathing or on coughing. She had had a temperature of 102 degrees F. and a roentgenogram had given evidence of pleural effusion. The thorax had been strapped. She had been in bed for about 1 week immediately thereafter and at frequent intervals in the following month. She had not entirely regained her strength since that time. She became tired easily. There was some cough but no expectoration. Six months previous to her admission she had had influenza with a moderate cough and pain on deep breathing. A diagnosis of pleurisy had been made again and her thorax had been strapped. The condition had cleared up after 2 weeks. Since that time she had suffered marked loss of strength, had become exhausted easily, and had had a slight non-productive cough.

General examination gave essentially negative results. The patient's weight was 109 pounds and her

Fig. 20. Roentgenogram taken after artificial pneumothorax. There are a few adhesions of the right lung to the upper portion of the intrathoracic tumor. No lesion is seen in the lung. Case 7.

height 5 feet and 6 inches. The concentration of hæmoglobin was 80 per cent; erythrocytes numbered 4,040,000, and leucocytes 7,600 in each cubic millimeter of blood. The Wassermann reaction of the blood was negative. The basal metabolic rate was +5 per cent. Roentgenological examination revealed a circumscribed shadow in the region of the right portion of the mediastinum, at the level of the fourth and fifth ribs posteriorly. It was thought to be due probably to metastasis. Operation was advised, but because the patient was weak she decided to go home and return in 2 months for operation.

The patient returned, September 17, 1929, at which time her symptoms were essentially unchanged. There was some increase in the cough but it was non-productive. The complaints of chronic nervous exhaustion were about the same. Roentgenologic examination at this time disclosed apparently no change in the size of the tumor. A diagnosis was made of postinfectious exhaustion, with associated right intrathoracic neurofibroma (Fig. 5).

September 21, 1929, under intratracheal ethylene and ether anæsthesia, right posterior thoracotomy, with removal of 15 centimeters of the fifth rib and section of the fourth rib, was performed. Transpleural complete removal of the neurofibroma from the upper portion of the posterior mediastinum was effected without difficulty. On exposure of the right thoracic cavity a small neurofibroma, measuring 4, 3, and 3 centimeters in various diameters, was seen in the upper portion of the posterior mediastinum, at the level of the third interspace. It was attached to the body of the vertebra at the angle of the spinous process and the vertebra. The thoracic aorta was just to the left of the tumor. The lung was very adherent, at various points, to the entire parietal pleura. These adhesions were not separated and probably were the result of the repeated attacks of influenza of which the patient had complained. The fourth rib was sutured, the lung was reinflated, and the thoracic cavity was closed without drainage. The pathologist reported neurofibroma weighing 28 grams.

There was very little reaction following operation. On the second day, the temperature was 100 degrees F. and the pulse rate 100 each minute. The temperature dropped to normal on the fourth day and the pulse rate to 90. There was a small amount of pleural effusion which did not require aspiration. The patient was dismissed from the hospital and from observation on the twenty-eighth day after operation, at which time the wound was entirely healed and the roentgenological examination gave evidence that the lungs were completely re-expanded and that no fluid had accumulated.

This patient returned 2½ months after operation for re-examination before going to a warmer climate because of the repeated respiratory infections. There was little change in her general condition and she continued to have a dry cough. Her appetite was better and her general condition was good. It was felt that her generally run-down condition had resulted from repeated pulmonary infections of which the tumor was not a contributing factor. The slight improvement which was obtained in the general condition was due to the fact that she ceased worrying about the tumor, which she had feared was malignant. From an operative standpoint, the convalescence was uneventful. She was up on the eighth day after operation and had practically no disturbances except moderate difficulty on deep breathing from the fourth day. A slight amount of pleural effusion developed but this was gradually absorbed without aspiration, which is usually the case unless there has been considerable trauma to the pleura (Figs. 6 and 7).

Case 3. A man, aged 56 years, consulted the clinic June 3, 1929, complaining of tumor of the right side of the thorax, and dizzy spells, of 3 years' duration. He stated that 3 years before, he first had noticed a small tumor, about 2.5 centimeters in diameter, on the upper right wall of the thorax. It was hard and had seemed fixed to the rib. Its growth had been gradual, and in about 1 year it had attained a size of about 6 by 4 by 4 centimeters. In 2 years the tumor had been about 8 centimeters in diameter. In the last year, its growth had been more rapid, until, at the time he came to the clinic, it involved practically the entire right half of the thorax. The patient had lost neither weight nor strength. In the last 6 months he had had a more or

less constant dull pain over the tumor and between the shoulder blades. Dyspnœa on exertion had been noted, and for the month before he was seen at the clinic, the patient also had noted pain in the right side of the thorax on deep inspiration. He first had noted a dry, brassy cough 3 months before he sought advice. This had become progressively worse and for the month previous to admission, bright red blood had been expectorated after a severe coughing spell. About 3 years previous to admission the patient had been refused life insurance because of high blood pressure; the systolic pressure had been 240 millimeters of mercury at that time and thereafter had varied from that level to 180 millimeters of mercury. The patient had been treated for hypertension by diet, medicine, and physiotherapy. He had had frequent headaches and dizzy spells, and his vision was poor.

General examination revealed the patient's weight to be 130 pounds. The pupils were slightly irregular, their reaction was normal, and early arcus senilis was present. The heart was enlarged to the left and there was a systolic murmur; there was marked sclerosis of the peripheral vessels. The systolic blood pressure was 245 and the diastolic, 130. The pulse rate was 78. There was a large mass involving practically the entire right thoracic cavity; it was firm, fixed, and slightly pulsile. Urinalysis gave essentially negative results. The concentration of blood urea was 24 milligrams in each 100 cubic centimeters. The concentration of hæmoglobin was 70 per cent; erythrocytes numbered 4,800,000, and leucocytes 7,200, in each cubic millimeter of blood. The Wassermann reaction of the blood was negative. Reflexes of the eyes were normal; the visual fields were roughly normal. Sclerosis of the retinal arteries was graded 2 and hæmorrhages were seen in the fundi. Electrocardiograms disclosed a cardiac rate of 78; sinus rhythm; very slight left ventricular preponderance; diphasic T waves in derivation 3; exaggerated P waves in derivation 2; notched P waves in derivations 1, 2, and 3; slurred QRS complexes in derivations 1, 2, and 3, and variable amplitude of the P waves in derivation 3. Roentgenological examination gave evidence of an intrathoracic tumor filling the upper two-thirds of the right thoracic cavity and resting on the spinal column posteriorly. There was a large protrusion through the anterior thoracic wall, with destruction of the second, third, and fourth ribs, anteriorly (Figs. 8 and 9). A diagnosis was made of a large intrathoracic fibromyxochrondroma filling the upper two-thirds of the right thoracic cavity and protruding about 12.5 centimeters through the anterior thoracic wall, with complete collapse of the upper and middle lobes of the right lung. Partial collapse of the lower lobe of the right lung also was noted.

Before a radical operation was done, a specimen was removed for diagnosis from the portion of the tumor which protruded through the anterior thoracic wall. This proved to be fibromyxochondroma. It was thought best to attempt complete removal of the tumor. July 3, 1929, under intratracheal ethylene and ether anæsthesia, right posterior mediastinotomy was performed with resection of a portion of the sixth rib and section of the seventh, fifth, fourth, and third ribs, posteriorly.

On exposure it was found that the tumor filled at least two-thirds of the cavity. The upper and middle lobes of the right lung were completely collapsed and flattened out over the surface of the tumor. The tumor filled the entire right side of the thorax anteroposteriorly and was pressing on the spinal column posteriorly. There was partial collapse of the lower lobe of the lung. The lung was so adherent over the capsule of the tumor that it was practically incorporated into the capsule in several places. It had ruptured into the lung, forming multiple small fistulas. The pulmonary tissue was separated from the surface of the tumor and was permitted to drop back. It was then found that the tumor was very adherent to the pericardium and to the mediastinal pleura of the left side. These adhesions were separated. After the intratracheal portion of the tumor had been separated, it was found that it was firmly attached to the third and fourth ribs anteriorly, which had been partially destroyed, and that the tumor apparently had originated from the cartilages of these two ribs. A small segment of each rib was excised, including the cartilages, and the entire intrathoracic tumor with that portion projecting through the thoracic wall was completely removed; that is, transpleural complete removal of the intrathoracic and extrathoracic tumor.

The lung was reinflated several times during the operation, and in spite of its marked compression, it seemed to be in good condition except for the small fistulas which were present, probably due to pressure. The thoracic cavity was washed out with physiological solution of sodium chloride, and the cavity was closed with intrathoracic drainage using a No. 30 French catheter. At the completion of the operation the patient was given a transfusion of 500 cubic centimeters of blood. The pathologist reported degenerating fibromyxochondroma weighing 1,844 grams.

The blood pressure had dropped to 100 and the pulse rate was 98 at the completion of the operation. The blood pressure gradually increased to 145, 6 hours after operation and the condition of the patient was satisfactory. The following morning, the blood pressure began to fall rapidly, with rapid increase in the pulse rate. The patient died within 10 minutes, essentially from cardiac causes.

Necropsy revealed hypertrophy of the heart (505 grams), probably the result of hypertension, and bronchopneumonia of the right lung, with atrophy of the kidneys (arteriosclerotic type). The tumor had been completely removed.

This case presents several points of extreme interest and importance. The most significant are that the tumor was benign and had been

permitted to grow until the patient was *in extremis*. Operation became imperative, and the risk was greatly increased because of the size of the tumor, particularly the intrathoracic involvement, with compression of the lung. This operative risk also was greatly enhanced by the marked general arteriosclerosis with hypertension, the cardiac hypertrophy, and the age of 56 years. I believe that these tumors should be removed before they have resulted in such marked intrathoracic involvement, with adhesions to the lung and to structures within the thorax.

CASE 4. A woman, aged 32 years, first consulted the clinic December 10, 1926, complaining of pain in the left upper portion of the thorax, of 3 years' duration. She had had good health until 3 years previous to her visit to the clinic, when she had begun to have a dull pain in the upper left part of the thorax, which had increased when she had become tired or excited. She had noticed the pain mostly at night. It had increased and occasionally had been present during the day. The patient had been short of breath, but this complaint had not increased. The pain had not radiated. There had not been any cough or expectoration. She had not noticed loss of weight. Ten months previous to her admission she had had a swelling in the right side of the neck, which had been thought to be a cyst, and had been removed. Two months previous to admission, a node had been removed from the neck and had been diagnosed as being tuberculous.

General examination at the time of the patient's first admission gave essentially negative results. Roentgenological examination revealed a dense, circumscribed shadow in the left upper posterior portion of the thorax at the level of the fourth and fifth ribs posteriorly. Apparently the cause of the shadow was benign (Fig. 10). The patient decided not to have an operation at this time.

The patient returned 5 months later stating that during her absence her condition had been as good as it had been previously. She had an occasional pain in the left side of the thorax anteriorly, at times going through to the upper part of the spinal column. Cough or hæmoptysis had not been noted. There had been no loss of weight and she weighed, at this time, 132 pounds, which was 3 pounds more than at her last visit. The roentgenogram, at this time, gave no evidence of change in the size of the tumor since her previous visit. The patient again returned home without treatment (Fig. 11).

The patient returned again August 5, 1929, stating that her general health had been normal until 6 months previous to her visit, when she had begun to notice loss of strength and that she became fatigued easily. The pain in the left side of the thorax had become much more marked 2 months prior to admission, and had been progressing rapidly; it had been severe for 1 month previous to admission. Because of the marked increase in the severity of the pain, the patient had returned to the clinic. The pain was situated in the left shoulder, spinal column, and left axilla. It was made worse by exercise and was somewhat relieved by rest. Cough or hæmoptysis was not present. There was loss of weight of 6 pounds in 2½ months, and marked loss of strength also had been noted.

General examination gave essentially negative results. The roentgenological examination revealed a circumscribed tumor on the left side of the upper mediastinum, between the third and seventh interspaces, posteriorly. The tumor contained a small amount of calcification, and had increased almost a third in size since the first examination (Fig. 12). A diagnosis was made of a left, intrathoracic fibromyxochondrosarcoma originating at the angle between vertebræ and ribs at the level of the fourth and fifth ribs.

August 10, 1929, under intratracheal ethylene and ether anæsthesia, left posterior thoracotomy was performed, with removal of the fifth rib and section of the sixth, fourth, and third ribs. On exposure, a large, solid tumor was found measuring 10, 9, and 8 centimeters in various diameters and firmly attached to the posterior thoracic wall. Its origin had been in the angle between the vertebræ and the ribs, at the level of the fourth and fifth ribs, and apparently had originated at the juncture of the fifth rib and the vertebra. There was a projection of the tumor into the mediastinum, between the arch of the aorta and the first portion of the descending aorta. It was in this portion of the tumor that malignant change was found. The tumor was very adherent to the aorta at this point. Transpleural removal of the entire tumor was effected, and the thoracic cavity was washed out with physiological solution of sodium chloride to remove the blood clots. The thoracic cavity was closed without drainage. The pathologist reported a hæmorrhagic, degenerating fibromyxo-osteochondrosarcoma, associated with a hæmangio-endothelioma weighing 220 grams (Fig. 13).

The patient stood the operation satisfactorily, and there was only moderate reaction. The pulse rate on the second day was 130 and the temperature 101 degrees F. The temperature gradually dropped to normal on the fourth day after operation and the pulse rate to 100. A pleural effusion developed which required aspiration on four occasions. The patient was dismissed from the hospital and from my care September 13, 34 days after operation, with the wound completely healed, in good general condition.

The patient returned for observation 1 month after dismissal, complaining of pain in the left shoulder which had become increasingly more severe. The pain had been most marked at night, and she had been unable to sleep because of it. There also had been some pain and difficulty in swallowing. The pain had been in the upper part of the thorax, the left shoulder and back, as it had been prior to

the operation. Roentgenological examination revealed evidence of partial collapse of the lung, and a small amount of fluid at the base. It was thought that the patient's condition was due to recurrence of the tumor, and she was given treatment by roentgen-ray. She again returned, 1 month later, with no relief of symptoms. The pain had become worse, with increase in difficulty in swallowing. A non-productive cough also had developed. The pain had been so severe that sedatives had been required for relief. Her condition became gradually worse and she died January 2, 1930, 5 months after the operation.

This case is of particular interest because there is reason to believe that the tumor was primarily benign but that later it underwent malignant change. It is unusual to have a patient with tumor under observation for this period of time, but the first roentgenogram, taken in 1926, compared with those taken 5 months later, did not disclose evidence of increase in the size of the tumor, and there was no increase in the clinical symptoms for 2½ years. There then was rapid increase in the severity of the pain, to a point that sedatives were required in 2 months' time. Pain was the predominant symptom throughout, which usually is the case in malignant tumors. The possibility of this being a benign tumor originally is also suggested by microscopic study of the tissue, for the greatest portion of the tumor was composed of benign tissue. That portion of the tumor which extended into the posterior mediastinum, underneath the great vessels, had been affected by a malignant change of a very high grade. The marked increase in the size of the tumor at the time of the patient's last visit to the clinic also was suggestive of a malignant condition. In the former roentgenograms, no change in size had been evident. Because of the high grade of malignancy and the extension of the tumor into the posterior mediastinum, the prognosis was grave, for the tumor probably had metastasized to the deeper structures of the mediastinum at the time of operation. Neither the operation nor the roentgen-ray treatment influenced the progress of the disease.

CASE 5. A woman, aged 35 years, consulted the clinic October 31, 1923, because of a goiter which had been present for 15 years and which had increased in size about 10 years prior to admission. There were no general symptoms except that she had become tired more easily than usual during the 6 months previous to her arrival at the clinic. She had been treated for pulmonary tuberculosis 8 years and 6 years previous to the time I saw her, but bacilli of tuberculosis had never been found in the sputum. Examination gave essentially negative results except for the revelation of the adenomatous goiter without hyperthyroidism. Roentgenograms of the thorax gave evidence of an old, calcified tuberculous lesion at the apex of the left lung. Thyroidectomy was advised, and was performed November 6, 1923. Microscopic examination of the goiter disclosed adenocarcinoma, graded 2, in a colloid and fetal thyroid gland.

The patient returned September 11, 1929, because of a severe pain in her back of 1 year's duration. She had had an indefinite pain in the epigastrium and back, and indigestion for 3 years previous to her second visit. She had been operated on elsewhere for disease of the gall bladder, without stones, but the gall bladder had been found to be normal. The appendix had been removed and the round ligaments of the uterus had been shortened. There had been no improvement in her condition for about 1 month, but she had had more or less constant trouble since that time with indigestion and pain in the back and epigastrium. For the year before her second visit, her symptoms had been getting progressively more severe and the pain in her back had been the most prominent symptom. This had been constant and dull, with acute attacks of sharp pain which had radiated around both sides of the lower dorsal portion of the thorax, to the epigastrium, and had been more marked on the left side. She had noticed some twitching in the muscles on the left side. The severe attacks of pain had occurred more often at night and had been followed by vomiting in many instances. She had had some difficulty in swallowing solid food for the 9 months previous to admission. There had been marked weakness and loss of strength. She had lost 20 pounds in 4 to 6 weeks. There was also a dry cough of several months' duration and shortness of breath of 15 months' duration.

General examination disclosed a lesion of the fifth, sixth, and seventh thoracic vertebræ. There was bilateral root pain and there had been some paresthesia and urinary disturbance. Urinalysis revealed only a few pus cells. The concentration of hæmoglobin was 11.6 grams in each 100 cubic centimeters of blood. The Wassermann reaction of the blood was negative. Leucocytes numbered 6,200 in each cubic millimeter of blood. The vocal cords functioned normally. Roentgenological examination gave evidence of marked destruction of the left half of the fifth, sixth, and seventh thoracic vertebræ due to erosion caused by tumor, probably neurofibroma. Fluoroscopic examination of the aorta and œsophagus gave negative results (Fig. 14). The roentgenographic shadow was very regular in outline, and suggested the possibility of a benign type of tumor. Because of the type and severity of the pain, and the old history of a carcinoma of the thyroid gland,

a clinical diagnosis of metastasis to the spinal column was made. It was thought best to keep the patient under observation for a month or 6 weeks, to note progress and to see if time would make a differential diagnosis possible. Considering the rapidity of increase in the recent symptoms, it was thought that if the condition were due to metastasis of a malignant growth, in a month the diagnosis could be definitely established and operation avoided. The patient returned in 3 months with marked improvement in her general symptoms. She had gained 8½ pounds in weight. The pain in the abdomen had disappeared. She could eat practically everything except cabbage, and the pain in the back, although still present, was not so severe. The cough was about the same. Roentgenograms of the spinal column did not give evidence of change in the size of the tumor, but possibly slight increase in destruction of the sixth vertebra. Lipiodol was injected into the spinal canal and some evidence of obstruction at the level of the tumor was seen. The second day following the injection of the lipiodol, the patient began to have pain in the left leg. The pain was of moderate severity; weakness and loss of strength of the muscles gradually developed, and for several days the patient was unable to be on her feet more than 10 to 15 minutes at a time. The reaction gradually subsided and was entirely gone in about a week. There was less pain in the back following the spinal puncture. Because of the improvement in her general symptoms and the absence of any definite growth of the tumor, exploratory mediastinotomy was advised (Fig. 15).

January 18, 1930, under intratracheal ethylene and ether anæsthesia, posterior left mediastinotomy was performed. A posterolateral incision was made; a portion of the sixth rib was removed posteriorly, and the periosteum was excised. Transpleural exploration of the thoracic cavity was performed. There was a mass extending about 2.5 centimeters above the level of the arch of the aorta, and extending underneath the descending aorta for about 6 centimeters. It was necessary to displace the descending aorta to the right to remove the tumor, which was posterior to it. The tumor was very vascular and infiltrated the surrounding tissues. Grossly, it appeared to be malignant. It was partially removed. Bleeding was controlled, and the thoracic cavity was closed without drainage. An operative diagnosis was made of metastatic carcinoma involving the fifth, sixth, and seventh thoracic vertebræ, with the tumor projecting backward and to the left of the arch of the aorta and the upper part of the descending aorta. The pathologist reported adenocarcinoma, graded 2. The tumor was of the thyroid type, for its cells had differentiated into columnar epithelium to a large extent, so that the growth bore a close resemblance to an exophthalmic goiter (Figs. 16 and 17).

Convalescence was uneventful except for slight pleural effusion which did not require aspiration. The patient was given treatment by radium on the twelfth day after operation, and was dismissed from my care on the twenty-fifth day, at which time the wound was entirely healed.

This case is of particular interest because of the unusual symptoms and course of the disease, the difficulty in establishing a definite clinical diagnosis, and the rarity of metastasis to the spinal column of carcinoma of low grade of the thyroid gland. The severity and type of the pain in the back suggested root pains of the upper thoracic nerves. The epigastric pain and digestive disturbances, with vomiting, suggested vagal irritation due to malignant infiltration which later had gone on to complete destruction of the vagus nerve, with relief of the digestive disturbance and improvement in the patient's general condition. This probably explains her improved general condition when she returned after 3 months, and the change in the quality of her voice probably was due to involvement of the left recurrent laryngeal nerve where it passed around the arch of the aorta. Aneurism was ruled out by fluoroscopic examination and absence of clinical signs. The roentgenological features were more suggestive of a benign than a malignant lesion. The sharply defined, rounded contour of the intrathoracic portion of the tumor suggested neurofibroma. There was more destruction of the spinal column than usually is found in benign lesions; scoliosis was present. There also was more marked obliteration of the intravertebral disks than usually is seen in benign lesions. There is very little risk to exploratory thoracotomy, and I believe that it should always be done in cases of this type, when a definite diagnosis cannot be made between malignant and benign tumors, because approximately 50 per cent of the lesions in this region are benign.

CASE 6. A woman, aged 46 years, consulted the clinic, August 20, 1929, in regard to a tumor of the right thoracic wall, of 12 months' duration. Five years prior to her visit to the clinic, the patient first had noted a small tumor in the upper central quadrant of the right breast. The tumor was fixed and did not move freely with the breast. She had been kept under observation by her home physician for 1 year, but definite growth of the tumor had not been noted. Because of slight pain in the tumor, she had been given bimonthly roentgen-ray treatment for the next 2 years, and 2 years prior to her coming

to the clinic radical amputation of the right breast had been performed. About 1 year after the operation, she first had noticed a small tumor, fixed to the rib, just to the inner side of the scar. The growth had been gradual for 9 months, but more rapid for the next 3 months, until at the time she came to the clinic, it was larger than the opposite breast. Roentgen-ray treatment had been given for 2 weeks prior to her visit, and the tumor had increased in size in spite of the treatment. Her general condition was good. There had been no loss of weight, there was no swelling of the arm, and her appetite was good.

General examination gave essentially negative results except for disclosing the large, fixed tumor of the right anterior portion of the thoracic wall, with dark red discoloration of the skin over it, and the scar of the previous radical operation. There was no regional adenopathy. Urinalysis gave negative results. The concentration of hæmoglobin was 78 per cent; erythrocytes numbered 5,050,000 and leucocytes, 7,100 in each cubic millimeter of blood. The Wassermann reaction of the blood was negative. Roentgenological examination gave evidence of a dense tumor in the middle of the right lower anterior portion of the thorax, arising from the mediastinum. A lateral view indicated that the tumor was large, was both intrathoracic and extrathoracic, and that it involved the midthoracic region. The intrathoracic portion extended half way to the spinal column. A clinical diagnosis was made of a tumor of the right thoracic wall, that probably was a recurring carcinoma of the right breast (Figs. 18 and 19).

August 28, 1929, under intratracheal ethyl chloride and ether anæsthesia, anterior thoracotomy, with partial removal of the third and fourth ribs, was performed. Because of the marked discoloration of the skin over the tumor anteriorly, it was thought best to make an anterior incision. The tumor was found to arise at the juncture of the cartilage of the third and fourth ribs anteriorly. There was considerable destruction of the ribs proximal to the cartilage. The ribs were resected well away from their region of degeneration, and the intrathoracic portion of the tumor was removed down to the parietal pleura, which was left intact. It was difficult to close the skin because of the scar from the previous operation and the depletion of the blood supply of the skin from frequent roentgen-ray treatment. The tumor measured 17, 14, and 5.5 centimeters in various diameters. An operative diagnosis was made of a large fibrosarcoma of the right anterior thoracic wall, with large intrathoracic extension, and the pathologists reported the tissue removed to be a fibrosarcoma, graded 1, in a fibromyxoma.

The patient's convalescence was uneventful, except for necrosis of the skin along the margin of the incision. She was dismissed from the hospital on the eleventh day after operation and from my care October 21, 1929, about 7 weeks after operation. The delay was due to the sloughing of that portion of the skin which was over the tumor. At the time of her dismissal, the wound was granulating at the base and it had almost healed. She was advised to return in 2 to 3 months for observation and for roentgen-ray treatment.

This case is of interest because it is probable that the original tumor, which had been thought to be in the breast, was in the anterior thoracic wall, for the patient stated that she had been able to feel a small tumor immediately after the operation on the breast. This may have been primarily a chondroma, for there was practically no growth in the tumor for 4½ years. It suddenly began to increase rapidly in size, which would indicate sarcoma with degeneration. It is not uncommon when abnormal conditions are immediately beneath the tissue of the breast to have them simulate tumors of the breast. I have seen 2 cases in which the complaint was of tumor of the breast, which proved to be instances of tuberculous abscess of the wall of the thorax underneath the breast. The prognosis in this case should be fair because of the low grade of the sarcoma. I believe that the prognosis would be very much better had the tumor been removed while it was in the dormant state.

CASE 7. A man, aged 48 years, consulted the clinic, January 27, 1930, in regard to a tumor of the right portion of the wall of the thorax which had been present for 2 years and 8 months. In May, 1927, 2 years and 8 months prior to his visit to the clinic, severe pain had developed suddenly in the right midaxillary line. The patient had had to stop work and had been taken home. He had been given a hypodermic injection to afford relief. The pain had been of a stabbing character and had necessitated morphine for 4 or 5 days. The pain had been augmented by inspiration, sneezing, or coughing. Following that attack the patient had had a dull, aching pain in this region, with attacks of severe pain similar to that which had appeared at the onset. He had had moderate cough, with some expectoration of mucoid material, but without blood or pus. One and a half years before he came to the clinic pain had developed in the right lower part of the back, with some indigestion, and he had been operated on for disease of the gall bladder. The gall bladder had been found to be normal. Two months previous to his consulting the clinic, severe pain in the right side of the thorax had suddenly developed again and gradually had grown worse, so that 1.5 grains (0.097 gram) of morphine had been required for relief. From then to the time the patient came to the clinic he had had more or less constant pain, for relief of which morphine and ether had been required. The most severe attack had lasted 2 days.

Following that attack, he had had constant soreness throughout the right half of the thorax. He had not lost weight and hæmoptysis had not occurred. Four years before, a carcinoma had been removed from the lower lip, with radium.

General examination gave essentially negative results, except that it revealed a fixed tumor in the posterior axillary line, measuring about 3 and 4 centimeters in various diameters. The concentration of hæmoglobin was 12.7 grams in each 100 cubic centimeters of blood. Leucocytes numbered 6,300 in each cubic millimeter of blood. The Wassermann reaction of the blood was negative. Roentgenological examination gave evidences of an intrathoracic and extrathoracic tumor, with destruction of a rib, and attachment to the sixth rib in the posterior axillary line. It seemed that it might be an osteochondroma. A clinical diagnosis was made of a tumor of the right wall of the thorax, questionably benign.

Preliminary artifical pneumothorax was induced January 29, and also January 30, 1930, to determine if the lung were adherent to the tumor or if there were a preliminary lesion of the lung. The lung collapsed away from the tumor, except for an adhesion at the upper part of the tumor. The lung was normal (Fig. 20).

Operation was performed February 1, 1930, under intratracheal ethyl chloride anæsthesia. Exploration was effected through a posterior lateral incision and the tumor was found to be attached to the sixth rib, a portion of which in the posterior axillary line it had destroyed. The destruction of the rib started posteriorly, about 7.5 centimeters from the spinal column. The anterior portion of the sixth rib was compressed beneath the fifth and seventh ribs. The tumor was vascular, with large dilated veins over its surface, and grossly it appeared to be of a high grade of malignancy. A specimen from the growth was removed for diagnosis. Radical operation was contra-indicated because the growth probably was metastatic, and secondary to the carcinoma of the lip. The wound was left partially open for insertion of radium. At operation a diagnosis was made of adenocarcinoma, graded 4, probably metastatic, involving the sixth rib on the right side in the posterior axillary line. The pathologist reported that the tissue removed was adenocarcinoma, graded 4.

The patient was given radium treatment on the sixth day following operation and was dismissed from my care about one week later.

This case presents the difficulty of establishing a definite clinical diagnosis from thoracic observations and roentgenological examination. The only suggestion of a malignant condition was the clinical history of severe pain, which is found more often in malignant lesions than in benign lesions of this size. The rounded outline of the tumor suggested a benign lesion, although the destruction of the rib suggested the possibility of a malignant lesion. Although adenocarcinoma, graded 4, was found at the time of operation, it undoubtedly was metastatic. Nevertheless, it is impossible definitely to determine the source of the growth; it is uncommon for carcinoma of the lip to produce this type of metastasis. Artificial pneumothorax in this case was helpful in the diagnosis in that it showed that the lesion was not a direct extension from the lung, for the lung was not attached to the tumor.

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THE EFFECTS OF THE ELECTROCAUTERY ON NORMAL TISSUES[1]

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THE increasing use of the electrocautery in all types of surgical procedures demands a careful study of the effects of electrothermal cutting on normal and diseased tissues. Originally introduced for the removal of tumor tissue, the method, with improved modifications and technical improvements, is being employed, by some surgeons, in place of the scalpel. In a recent article on the use of electrocautery, Lowry states that "Surgery is passing from the age of iron and steel to the period of electrical development."

Clark, Morgan, and Asnis studied the histological effects of electrocautery on tumor tissue removed with this method and noted desiccation and necrosis of the cells near the line of incision. They further studied the effects of the cautery on the skin, subcutaneous tissue, and muscle of rabbits and guinea pigs with both desiccating and coagulating currents. In addition to the histological changes mentioned, they observed round cell perivascular infiltrations.

The use of electrocautery has been advocated by Scott in breast carcinomata; by Cushing for the enucleation of brain tumors; by Kelly for pelvic surgery; by Clark, Morgan, and Asnis, McFee and Wyeth, for cancers of the skin, mouth, and tongue.

An effort was made to study experimentally the effect of simple incisions with the electrocautery desiccating knife in the skin, muscle, liver, spleen, and kidney of normal adult albino rats, and to compare the manner and rate of repair of such wounds with corresponding incisions made with the scalpel. In these experiments, the electrocautery incisions were made with a very fine needle, the desiccating current of the Engeln high frequency electrocautery machine being used. The scalpel incisions were made with a small bladed surgical scalpel. All procedures were done with aseptic technique.

The experiments were divided into four groups. In the first group, 5 rats were used. With the electrocautery, a simple abdominal incision, 2 centimeters in length, was made through the skin, subcutaneous tissue, and muscle, parallel with and to the right of the midline. On the opposite side, a similar incision was made with the scalpel. The edges of the wound were approximated with silk sutures. The rats were killed at intervals of 1, 2, 4, 7, and 11 days and sections made of the wounds.

PROTOCOLS

Rat 1. Electrocautery wound, 24 hours after incision. There is a large area of necrosis extending from the skin to the peritoneum on both sides of the line of incision. The muscle cells have lost their nuclear elements. Small foci of polymorphonuclear leucocytes are present in the interstitial tissue of the muscle. Along the suture line there is an exudate of polymorphonuclear leucocytes and red blood cells and serum. Capillaries are congested and many of the smaller vessels are thrombosed (Fig. 1).

Rat 2. Scalpel wound, 24 hours after incision. A very narrow cleft extends from the skin to the peritoneum, corresponding to the line of incision. The space is filled with a blood clot. The surrounding tissue appears viable.

Rat 3. Electrocautery wound, 11 days after incision. There is a cleft between the ends of normal epithelium, corresponding to the line of incision, filled with a very highly vascular and densely cellular granulation tissue. This protrudes above the level of the skin and is covered with a membrane of polymorphonuclear cells, fibrin, cellular débris, and bacterial clumps. The cellularity of the granulation tissue diminishes from above and appears more œdematous in the deeper portions. In the region of the muscular layer, the granulation tissue contains numerous giant cells, each with ten to twenty peripherally arranged nuclei (Fig. 2).

Rat 4. Scalpel incision, 4 days after operation. The line of incision is healed and the epithelium has grown across the surface of the tissue. There is an irregular band of fibrous connective tissue extending from the skin to the peritoneum (Fig. 3).

It will be noted from the protocols and Figures 1, 2, and 3 that the electrocautery produced extensive necrosis for a wide area about the line of incision, that suppuration appeared in the region of the necrosis, that the necrosis produced by the cautery acted as a foreign body irritant, stimulating the pro-

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duction of foreign body giant cells, and that healing was markedly delayed. The scalpel incisions healed in 3 to 4 days, with very little scar formation and often by primary union. The cautery incision was not healed after 12 days. Healing was slow with extensive scar formation and with a tendency to infection. It must be remembered that the rat is unusually resistant to ordinary pyogenic infection.

In the second group of experiments, 14 rats were used. In 7, scalpel incisions, 1 centimeter in length, were made in the liver. There was considerable bleeding. In the remaining 7 rats, similar sized incisions were made in the liver tissue with the electrocautery. There was practically no bleeding. The rats were killed at intervals of 1, 2, 3, 4, 6, 8, and 14 days and sections made of the liver wounds.

PROTOCOLS

Rat 5. Scalpel incision, 1 day after operation. There is a small wedge shaped cleft in the liver tissue filled with a clot. The surrounding liver tissue is intact.

Rat 6. Electrocautery incision in the liver, 1 day after operation. There is a large irregular area of necrosis. The edge of the necrotic area ends abruptly without any transitional zone. The surrounding liver tissue is deeply congested. There are small areas of hæmorrhage in the necrotic region. The capsule on one side of the necrotic area is covered with a layer of desquamated endothelial cells. Just beneath the capsule there are large irregular spaces in the necrotic tissue indicative of dehydration (Fig. 4).

Rat 7. Scalpel incision, 9 days after operation. The wound is entirely healed. There is a small narrow wedge of dense, fibrous, connective tissue corresponding to the line of incision.

Rat 8. Electrocautery incision, 11 days after operation. The area of necrosis is very much smaller. It is practically replaced by a sharply defined area of granulation tissue. A few small areas of necrotic liver tissue are still present in the scar, surrounded by dense fibrous tissue and numerous foreign body giant cells. In addition there are numerous newly formed capillaries in the granulation tissue. The surface of the scar is depressed. There are still a few small areas in the necrotic spaces indicative of dehydration. The tissue about these spaces contains hæmosiderin pigment (Figs. 5 and 6).

From the protocols and Figures 4, 5, and 6, it is evident that the electrocautery produces (1) extensive necrosis for some distance from the line of incision and (2) the necrotic tissue acts as a foreign body, stimulating the formation of foreign body giant cells in the connective tissue about the area of necrosis. In the liver, the scalpel wound healed in short time, leaving a barely recognizable scar. Some advantage was found with the cautery in controlling the capillary bleeding in the liver. The liver is particularly susceptible to the necrotizing effects of the cautery.

In the third group, 12 rats were used. In one-half of these, a single small incision was made in the spleen with the scalpel. In the other half a similar incision was made in the spleen with the electrocautery. The rats were killed at intervals of 1, 2, 4, 6, 8, and 14 days and the wounds sectioned.

PROTOCOLS

Rat 9. Scalpel wound, 1 day after incision. There is a small wedge shaped cleft in the spleen filled with a blood clot. The surrounding tissue is normal (Fig. 7).

Rat 10. Electrocautery, 1 day after incision. There is a large wedge shaped area of necrosis in the spleen. There is very little tissue reaction at the border of the necrotic area. On the surface, however, there is a large accumulation of polymorphonuclear leucocytes and fibrin (Fig. 8).

Rat 11. Scalpel wound, 6 days after incision. There is a very thin scar in the spleen extending from the capsule into the pulp. It consists of dense fibrous connective tissue in which are present a few round cells and hæmosiderin pigment (Fig. 9).

Rat 12. Electrocautery, 8 days after incision. The irregular wedge shaped area of necrosis described in the earlier section is replaced in part by dense granulation tissue in which small islands of necrotic tissue are still present. About the areas of necrosis are numerous foreign body giant cells (Fig. 10).

From the protocols and the Figures 7, 8, 9, 10, it is seen that in the spleen as in the liver, skin, and striated muscles, extensive necrosis follows in the wake of the cautery. The necrosis acts as a foreign body, stimulating the formation of numerous foreign body giant cells after a period of 8 days. Healing is delayed.

In the fourth group, 12 rats were used. In half of these, small incisions were made in the right kidney with the scalpel and in the other half, a corresponding incision was made with the electrocautery. The rats were killed at intervals of 1, 2, 4, 6, 11, and 15 days and sections made of the wounds.

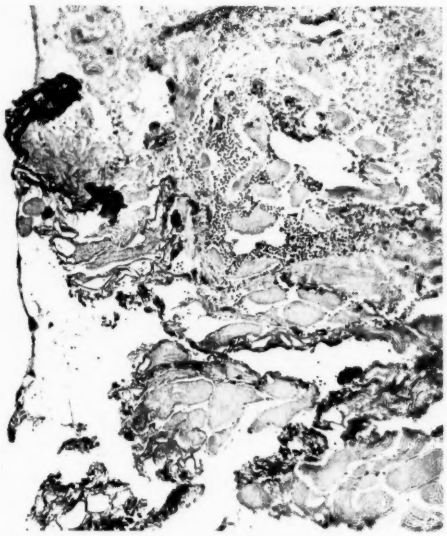

Fig. 1. Extensive necrosis of skin 24 hours after cautery incision. ×65.

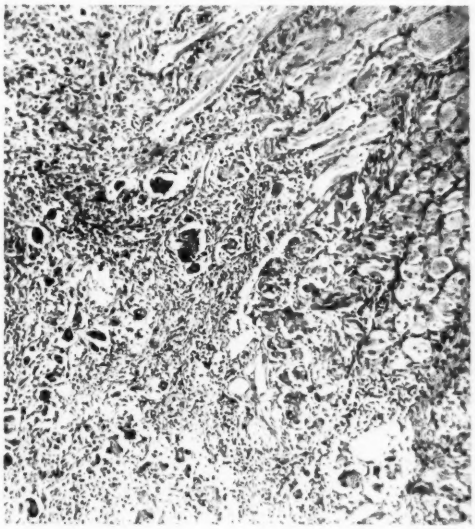

Fig. 2. Numerous giant cells in specimen removed 11 days after cautery incision of skin. ×65.

Fig. 3. Photomicrograph of section removed 4 days after incision of skin with scalpel. ×65.

PROTOCOLS

Rat 13. Scalpel wound, 1 day after incision. Extending from the capsule to the medulla through the cortex, there is a narrow wound filled with a blood clot. The surrounding kidney tissue appears normal (Fig. 11).

Rat 14. Electrocautery wound, 2 days after incision. There is a large area of necrosis in the cortex, extending into the medulla. For a consider-

Fig. 4. Liver specimen removed 24 hours after cautery incision showing necrosis and vacuolization. ×80.

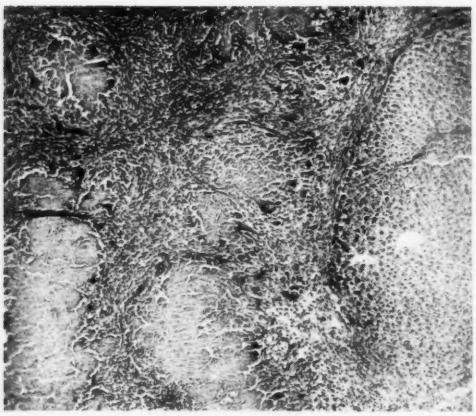

Fig. 5. Cautery incision of liver 11 days after operation showing foreign body giant cell reaction around zone of necrosis. ×80.

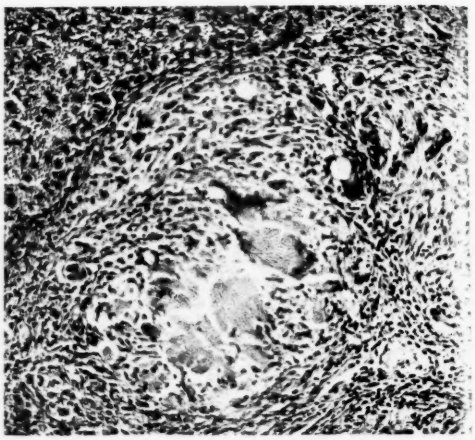

Fig. 6. Giant cell formation 11 days after cautery incision of liver. ×80.

able area on either side of the line of incision there is a zone of hæmorrhage about the zone of necrosis. Close to the margin of the necrotic area, the kidney parenchyma is destroyed and replaced by a homogeneous, blood stained tissue. In the area of necrosis, ghosts of kidney glomeruli and tubules are still visible. Beneath the capsule, the tissue is

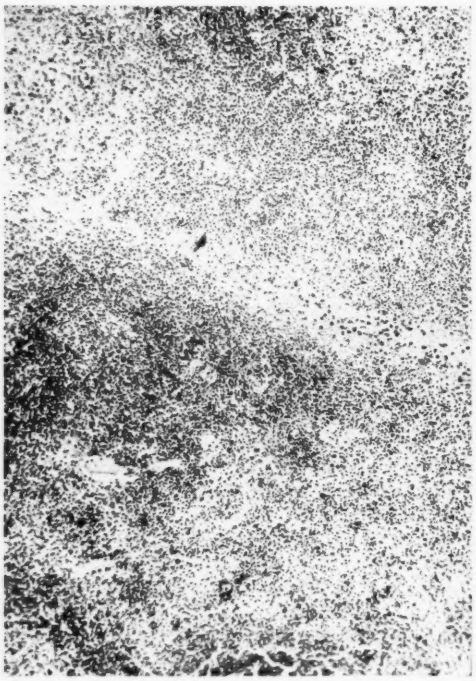

Fig. 7. Specimen removed 24 hours after scalpel incision of spleen. ×65.

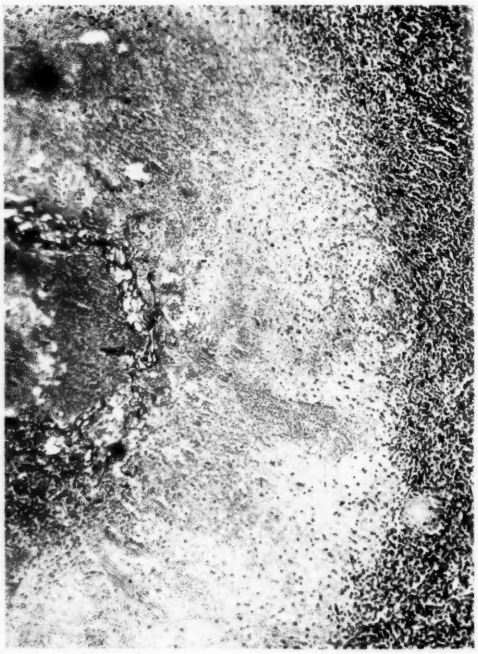

Fig. 8. Extensive necrosis 24 hours after cautery incision of spleen. ×65.

Fig. 9. Specimen removed 6 days after scalpel incision of spleen. ×65.

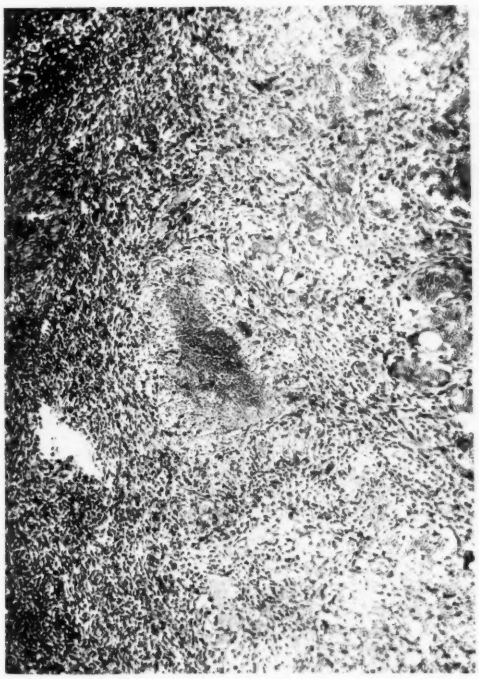

Fig. 10. Foreign body giant cell reaction 8 days after cautery incision of spleen. ×65.

honeycombed with numerous cyst-like spaces, indicative of extensive dehydration (Fig. 12).

Rat 15. Scalpel wound, 6 days after incision. The line of incision is healed. There is a thin band of scar tissue extending through the kidney.

Rat 16. Electrocautery, 15 days after incision. There is an irregular wedge shaped area extending from the capsule to the medulla in which the kidney parenchyma is replaced by granulation tissue. There are several areas of necrotic tissue in the granulation tissue. These are surrounded by dense fibrous connective tissue which extends from the capsule inward. The granulation tissue contains numerous fibroblasts, and about the areas of necrosis are many multinucleated foreign body giant cells. In places these giant cells appear to be formed by the fusion of regenerating tubular epithelium (Fig. 13).

From the protocols and Figures 11, 12, 13, it is seen that the cautery produces in the kidney as in other organs, extensive necrosis, a foreign body giant cell reaction evident after 10 days about the area of necrosis and marked delay in the healing and repair.

RESULTS OF OUR STUDY

It is obvious that the use of the electrocautery in normal tissue results in extensive necrosis. The presence of necrosis produces a point of lowered resistance and encourages suppuration. The necrotic tissue, even in the smallest incision, is sufficiently extensive to act as a foreign body and to stimulate the formation of numerous foreign body multinucleated giant cells. In striated muscle they arise from the regenerating muscle sheath, in the liver from the reticular elements, in the spleen, where they are most numerous, also from the reticular elements, and in the kidney they seem to arise from the epithelial cells of regenerating tubules. It is of interest that in every organ they appear after a lapse of 8 or 9 days.

The cautery incision heals slowly, for it produces extensive death of tissue and introduces elements that act to retard the process of repair.

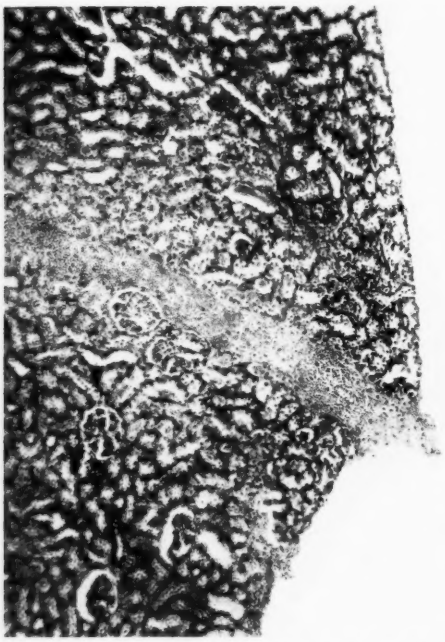

Fig. 11. Specimen 24 hours after scalpel incision of kidney. ×110.

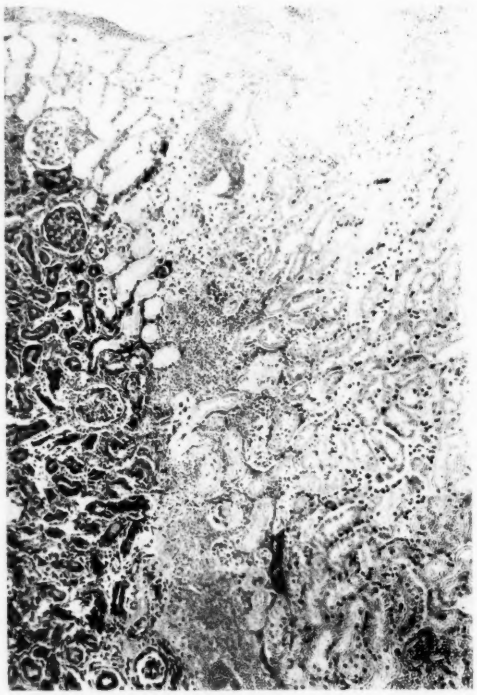

Fig. 12. Large area of necrosis 48 hours after cautery incision of kidney. ×65.

Another inherent danger in the use of the cautery is the occurrence of secondary hæmorrhage. This may occur where the larger vessels are sealed with a coagulated mass which becomes necrotic and may subsequently slough away. It must be remembered that we are here dealing with normal tissue. The results obtained suggest that more severe injury may result in diseased tissue following electrocautery. The use of the cautery in incising infected tissue is unsound and unphysiological, because it adds more necrosis to the burden of repair. Its promiscuous use for making incisions through healthy tissue is certainly to be discouraged.

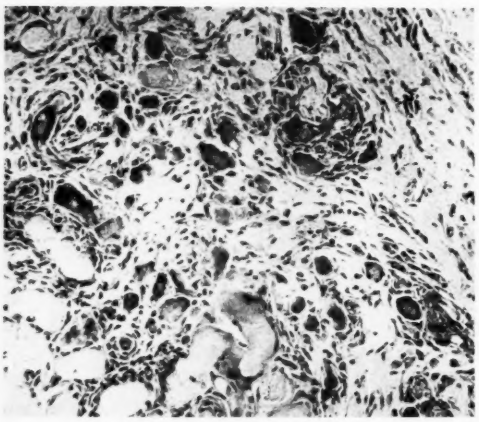

Fig. 13. Giant cells 15 days after cautery incision of kidney. ×195.

The employment of electrocautery in cancer tissue has many drawbacks. The wounds heal more slowly and readily suppurate. It has been suggested that, by sealing the lymphatics, the method prevents the absorption of tumor cells and also destroys isolated foci along the line of incision. It is probable that immediate absorption is prevented by coagulation necrosis of the lymphatics cut across. Histological studies indicate that lymphatic channels rapidly regenerate in granulation

tissue. Where wide excisions of malignant tissue is made, it is essential to resect the regional lymph nodes. This blocks the lymphatic drainage. Where all lymph channels are thus blocked, brawny œdema results with resultant lowered tissue vitality. The cautery only strengthens this vicious cycle.

The use of the electrocautery is warranted, however, when it is definitely desired to destroy tissue, in places inaccessible to the scalpel and when the control of capillary bleeding is difficult. The promiscuous use of the electrocautery, however, in lieu of the scalpel is to be condemned. It has a definite place in surgical technique and should be used only when definitely indicated. A knowledge of the pathological changes following in the wake of the electrocautery will help in evaluating its proper application.

SUMMARY

A study of the effect of the electrocautery incision in the skin, muscle, liver, kidney, and spleen in normal adult albino rats was made. It was found that the electrocautery incision produces extensive necrosis which acts as a foreign body with a resulting foreign body giant cell reaction. The advantages and the disadvantages of the electrocautery are discussed. The promiscuous use of the electrocautery is to be discouraged.

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PERINEPHRITIC ABSCESS[1]

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BECAUSE perinephritic abscess may symptomatically simulate intra-abdominal, orthopedic, neurologic, respiratory, or lower urinary tract disease, the lesion is not only of general surgical interest but merits medical consideration as well. Frequently clinical evidence of perirenal involvement is lacking. The herewith reported study of 83 cases of perinephritic abscess admitted to the urological, surgical, and medical wards of Bellevue Hospital during the past 10 years seems of particular interest since there is pointed out statistically the possible confusion of symptoms, the diagnostic difficulties encountered, the character and high incidence of complications, and finally that in a third of the cases autopsy disclosed this lesion (unsuspected during life) either as the direct cause of death or as a fatal complicating disease.

ETIOLOGY

Perinephritic abscess is predominantly a disease of males. Sixty-seven of our cases were of this sex, whereas but 16 were women. The only explanation I know of is the greater male incidence of cutaneous wounds due to occupational trauma.

Right and left sided involvement is about equal. We found the abscess on the left side 41 times, on the right 40, and bilaterally twice. While abscess extension from one side to the other may occur, bilateral involvement usually means a blood stream infection with bilateral cortical abscess formation.

Age is not a great factor although nearly half of our patients were between the ages of 20 and 40 years (Table I). The youngest, a female of 13 days, is of special note in that 7 days after delivery a staphylococcus thumb infection developed, was incised, and septic death occurred 6 days later. Autopsy revealed bilateral, multiple, cortical abscesses with an early perinephritic abscess of one side.

Etiologically perirenal abscess may best be classified according to its intrarenal or extrarenal origin. The former includes all types of infection, often associated with trauma, stone, or tumor and nearly always gives clinical evidence of urinary tract involvement. Ureter or kidney perforation by catheter is, for example, an intra-urinary tract trauma; I know of 2 such cases. One patient fell, traumatized the kidney, developed an extensive perirenal hæmatoma which, infected, became a clinical perirenal abscess. In another instance (4), the infection spread through a ruptured diverticulum of the upper ureter (Fig. 1).

Perirenal abscess of extrarenal origin is notoriously free of urinary findings or symptoms. In the absence of renal infection, one must assume the arrival of bacteria in most cases either through the retroperitoneal lymphatic channels or through the blood stream from some distant focus. We know that in some instances the abscess occurs as an extension of a pelvic extravasation, appendiceal abscess, postpartum infection, or from penetrating trauma (gunshot). Infection may also ascend through the lymphatics from the bladder, seminal vesicles, prostate, fallopian tubes, perirectal or other pelvic tissues. Recently I saw a woman 46 years of age with an enormous (10 ounces) staphylococcus retroperitoneal fat abscess; the kidney on this side was removed 4 years ago. Loin pain, fever, and signs of abscess developed 3 weeks following an illness diagnosed influenza.

Clinico-pathological studies, however, decidedly indicate the renal origin (especially cortical or subcapsular) of most perinephritic abscesses. Anatomically the renal parenchymal infection whether originating in the kidney pelvis or whether blood borne from some distant focus to the renal end arteries extends to the cortex, a subcapsular abscess forms, ruptures, and perirenal fat suppuration ensues. While most of these abscesses will eventually become clinically manifest, observation in a recent autopsy case at Bellevue indicates that the disease may become local-

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Fig. 1. Pyelogram in Stevens' case of perinephritic abscess secondary to rupture of ureteral diverticulum. Extravasation of the pyelographic medium into the perirenal abscess mass is noteworthy.

ized and heal by encapsulation. In this patient, a male of 44 years, dead of bile-duct carcinoma, the upper pole of the left kidney showed scarring with an attached perinephritic abscess 2 centimeters in diameter enclosed in a calcified fibrotic wall. I have not found record of a similar case. A far more common method of healing is that of extensive perirenal sclerosis. Due to this sclerosis, marked renal and ureteral compression or distortion with the production of symptoms frequently occurs.

An understanding of the perirenal anatomy is important. The perirenal fat is enveloped by a prerenal and retrorenal fascial layer united above but open below and here continuous with the loose tissues of the true pelvis. In this infrarenal portion one finds both perirenal and peri-ureteral fat. Laterally the envelope is closed but medially the layers pass over the great vessels and may or may not fuse with those of the opposite side. Surrounding this fascial sheath is another layer of fat—the pararenal fat—thickest

Fig. 2. Obliteration of the psoas muscle outline with spinal curvature away from the perirenal abscess.

posteriorly where it overlies directly the large lumbar muscles. Well supplied like the perirenal fat with lymphatics and terminal blood vessels, metastatic abscess formation may also occur here and be clinically indistinguishable from true perirenal abscess.

A perinephritic abscess which has penetrated the posterior fascial layer enters the pararenal fat, usually extends upward, and frequently leads to subphrenic abscess as in 12 of our cases. This latter process may, as I have seen in a case of perirenal abscess secondary to stone pyonephrosis, perforate the diaphragm and cause suppurative pleurisy and terminal pneumonia. While perinephritic abscesses rarely rupture externally, in 2 of our patients this did occur; if neglected, a chronic sinus may result. The fistulous opening is sometimes quite distant from the abscess site.

TABLE I.—AGES

Years	Cases
Under 5	2
5 to 9	2
10 to 19	11
20 to 29	24
30 to 39	14
40 to 49	13
50 to 59	10
60 to 70	5
Over 70	2
	83

Youngest 13 days; oldest 74 years

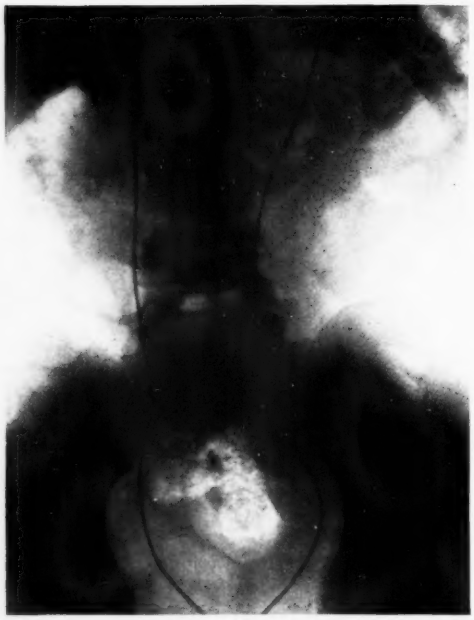

Fig. 3. Perinephritic abscess in boy of 7 years. A slight spinal curvature is seen. More striking is the lateral displacement of the kidney as indicated by the course of the ureter catheter. Pyelography confirmed this.

Fig. 4. Perirenal extravasation of pyelographic media in case of perirenal abscess secondary to pelvic rupture. The renal pelvis was firmly occluded by a stone.

Staphylococci are the invading organisms in fully 80 per cent of all cases and are metastatic from a distant suppurative process. Next in order of frequency are streptococci and colon bacilli, although pneumococci and gonococci are at times the etiological agent (Table II). Metastatic perirenal abscess may develop during the course of an acute infectious disease, more particularly in pneumonia, meningitis, influenza, variola, scarlatina, or typhoid. The most common suppurative foci are infected skin lesions (eczema, wounds, cellulitis, furuncles, carbuncles, paronychiæ), osteomyelitis, respiratory infections (nasopharyngitis, tonsillitis, otitis media), gastro-intestinal lesions, especially appendicitis, and less commonly infections of the genital tract, the prostate in particular. One case was unusual; the patient, a drug addict, developed a staphylococcus perirenal abscess secondary to a hypodermic abscess. In about half of all cases the primary focus cannot be determined (Table III). Bilateral embolic infection is rare; we found but two instances (2.5 per cent). In one of these, a suppurative appendicitis was the primary focus.

PATHOLOGY

Perinephritic abscess may be present as a small localized lesion or may extensively surround the kidney and even invade distant areas, for example: subphrenic, pelvic, or scrotal cavities. Thoracic or peritoneal extension sometimes occurs. In one of our cases the abscess burrowed down to surround the rectum. A primary axillary staphylococcus abscess indicated that the perirectal involvement was secondary rather than primary.

If the abscess is of extrarenal origin, the kidney may show only compression. Most often, however, the disease is of intrarenal genesis; the involved kidney then may show localized, diffuse cortical, or universal parenchymal suppuration, subcapsular abscesses, renal carbuncle, or there may be evidence of long standing disease—stone, tumor, pyonephrosis, hydronephrosis, pyelonephritis. The

TABLE II.—ORGANISMS FOUND IN PERIRENAL PUS

	Cases
Staphylococcus aureus	34
Staphylococcus albus	1
Bacillus coli	5
Streptococcus	3
Pneumococcus	1
No examination	39

TABLE III.—FOCI OF INFECTION

	Cases
Skin	
Extremities	8
Middle ear	1
Neck	3
Upper respiratory	9
Genito-urinary tract	
Prostate	9
Kidney stone	4
Old kidney infection	2
Ureter suppuration	1
Suppurative endometritis	1
Gastro-intestinal tract	
Appendix	3
Colon	1
Diabetes	3
Unknown	36

primary location of the abscess is often hard to determine; the lower and upper renal poles seem to be involved with equal frequency. While most abscesses will be found on the posterior renal surface, unless one inspects the anterior surface well some lesions will be overlooked. Localized anterior abscesses are not uncommon and because they immediately underlie the posterior peritoneum are especially apt to simulate symptomatically acute intra-abdominal disease (Table IV).

TABLE IV.—LOCATION OF ABSCESS

	Cases
About kidney	30
Upper pole	3
Subdiaphragmatic	12
Lower pole	9
Retrorenal	8
Extending to pelvis	6
Associated empyema	1
Kidney involvement	
Cortical abscess	7
Multiple diffuse abscess	8
	83
None or not recorded	68

TABLE V.—SYMPTOMS

	Cases
Pain	
Loin	64
Abdominal	8
Leg	7
Respiratory	6
Chest	5
Hip	3
Testicle	2
Cough	7
Dyspnœa	1
Difficult breathing	4
Acute gastro-intestinal upset	6
Duration of symptoms	
Less than 24 hours	3
24 to 48 hours	2
3 to 7 days	13
8 to 14 days	17
15 to 21 days	18
22 to 28 days	6
Over 4 weeks	16
Not recorded	8
	83

Shortest 6 hours; longest 7 weeks

SYMPTOMS

An acute onset in an otherwise healthy individual is the rule. Fever, pain, gastro-intestinal disturbances, and urinary frequency are the more common complaints (Table V). Fever is probably present in every case, although it is interesting to observe the slight temperature rise (.4 to .6 degrees F.) in some cases having gross abscess formation. Fever is most often preceded by chills and if the infection is severe the chills may be followed by drenching devitalizing sweats.

Pain was totally absent in but 6 of our cases. As a rule it is localized in the loin and more particularly the costovertebral angle. It may radiate or be referred. Referred pain in perirenal abscess is particularly interesting from the orthopedic standpoint. In 3 of our patients, the pain localized in the hip and twice hip joint disease was diagnosed by an orthopedist. It should be noted that not infrequently in children perirenal abscess overlying the psoas muscle will cause hip flexion, excruciating pain in the hip-joint region, and commonly leads to the diagnosis of hip-joint disease. In one of our patients, the only symptom was an intense pain in the right knee; by a fortunate delay during which time the correct diagnosis of perirenal abscess was established, anticipated knee exploration was averted. Because of the symptoms produced, perirenal abscess is sometimes incorrectly diagnosed spinal tuberculosis or psoas abscess.

Twice the chief complaint was intense pain in the isolateral testicle. This is obviously spermatic reference and is a phase of the same process giving rise to ureteral or renal colic as a symptom of perirenal abscess. Colic was

TABLE VI.—SYMPTOMS AND PHYSICAL EXAMINATION

	Slight	Marked	Total positive	None	Not recorded
Nausea			40	29	14
Vomiting	30	6	36	31	16
Dysuria			18	38	27
Frequency	5	34	39	21	23
Hæmaturia	1	9	10	57	16
Pyuria (gross)			12	25	56
Rigidity	6	52	58	19	6
Mass felt	34	25	59	6	17
Urinalysis					
Albumin	36	8	44	33	6
Sugar			6		
White blood cells	37	21	63	20	5

a symptom in but one case. Another patient's only pain was in the urethra on voiding; no lower tract disease was demonstrable.

While most patients describe the local loin pain as sharp and stabbing, in some it is only a dull ache. Both types of pain are aggravated by motion. This is readily understood when we remember that spasm and rigidity of the psoas and erector spinæ muscles is produced by the overlying inflammatory abscess mass. A lordosis with the concavity toward the abscess not infrequently accompanies the spinal rigidity and when demonstrated roentgenographically is of diagnostic aid.

In 10 per cent of our patients the pain was entirely abdominal and so strongly indicated laparotomy that normal appendices were twice removed and twice perinephritic abscess was discovered through the opened abdomen. When high right abdominal pain is present, cholecystitis is sometimes incorrectly diagnosed as in one of our cases. Conversely in one patient (not included in this series) in whom the diagnosis of perirenal abscess seemed undisputable the disease was proved to be acute cholecystitis and hepatitis; cholecystotomy cured.

Respiratory pain or difficulty most often bespeaks a complicating subphrenic abscess and may be so distressing as completely to overshadow loin signs. Cough due to phrenic irritation was present in 7 of our patients and is a symptom seldom mentioned in this conjunction.

In 6 instances an acute gastro-enteritis with nausea, vomiting, and diarrhœa heralded the onset. In such event, the extreme physical depletion resulting therefrom seriously handicaps and rarely may prevent ultimate recovery. In one case this type of onset led to the diagnosis of food poisoning, in another to that of typhoid fever.

TABLE VII.—DIAGNOSTIC PROCEDURES

	Cases
Cystoscopy and ureteral catheterization	
Of diagnostic help	14
Of no diagnostic help	17
Confused the diagnosis	2
Total cystoscopies	33
X-ray examination	
Of diagnostic help	22
Of no diagnostic help	23
Patients examined	40
Leucocyte count*	
Under 10,000	5
10,000 to 15,000	23
15,001 to 20,000	20
20,001 to 25,000	13
Over 25,000	7
	68
Lowest 5,500; highest 38,500	
Polymorphonuclear count	
Per cent	
Under 75	7
75 to 80	15
80 to 90	30
Over 90	6
	67

*Only highest count recorded.

Symptoms of lower urinary tract disease may help to confuse the clinical picture and diagnosis. Nearly half of our patients complained of urinary frequency. A quarter of them reported no frequency; in the remainder this symptom was not recorded. As a rule the frequency is painless and is reflex from the upper tract inflammatory involvement. In only 18 cases was dysuria reported as a symptom. Pyuria was noted by 12 patients and hæmaturia by 10. The pus and blood in the urine usually originate in the inflamed kidney (Table VI).

In some instances the symptoms so closely simulate those of neurologic disease that differential diagnosis becomes unusually difficult. Meningitis and encephalitis were diagnosed in 2 cases each, so striking was the clinical similarity.

The long duration of marked symptoms of perirenal abscess in many of our cases is indeed a complimentary commentary on the human defensive mechanism. In a fifth of our patients, symptoms had been present over 4 weeks, in one instance for 7 weeks. One

TABLE VIII.—BLOOD CHEMISTRY

	Cases
Non-protein nitrogen	
Under 30 mgm./100 c.cm.	10
30 to 50 mgm.	19
Over 50 mgm.	3
Creatinin	
Under 1.5 mgm./100 c.cm.	16
1.5 to 2.5 mgm.	16
2.6 to 4 mgm.	2
Over 4 mgm.	3
Blood cultures	
Staphylococcus aureus	6
Streptococcus hæmolyticus	2
Bacillus coli (spleen)	1
Negative	11
Total cases	20

TABLE IX.—COMPLICATIONS

Pulmonary	
Pneumonia	8
Empyema	3
Pleural effusion	1
Embolus	1
Cardiac	
Pericarditis	3
Acute endocarditis	1
Genito-urinary	
Suppurative prostatitis	5
Prostatic abscess	2
Acute epididymitis	2
Suppurative seminal vesiculitis	2
Suppurative ureteritis	2
Ureteral stricture	1
Thrombosis of kidney	1
Uræmia	4
Abdomen	
Peritonitis	3
Pelvic cellulitis	2
Pertussis	1
Sepsis	11
Metastatic abscess	
Sternum	2
Scapula	1
Liver	3
Ribs	1
Lungs	6
Cutaneous lymphangitis	1
Repocketing of pus	1
Otitis media	1
Paralytic ileus	1

patient was seen 6 hours following acute onset. In over half, symptoms existed from 3 days to 3 weeks (Table V).

DIAGNOSIS

There are, indeed, few lesions in which the diagnosis may be more difficult than in perirenal abscess. The following is a résumé of the various diagnoses made in those cases in which the physical findings were not specifically those of perirenal abscess: encephalitis, typhoid fever, meningitis, pulmonary tuberculosis, bronchitis, intercostal neuralgia, endocarditis, cholecystitis, hypernephroma, ecchinococcus cyst, tuberculosis of the lumbar spine, tuberculosis of the sacro-iliac joint, psoas abscess, hip-joint disease, surgical disease of the knee and, in several instances, malaria and influenza. In some of these patients the correct diagnosis was ultimately established during life, in others at autopsy.

Abdominal rigidity was found in 58 of our patients and in 59 a definite mass was palpated. Frequently the rigidity is localized to the muscles of the loin only, but in some instances the entire abdominal musculature of the affected side is splinted by spasm. Rebound tenderness is seldom elicited. Frequently rigidity will be localized only in the costovertebral angle and along the erector spinæ muscles producing a "poker back."

Tumefaction is found in at least 75 per cent of all cases and when present is an invaluable diagnostic finding. A low loin mass may simulate retrocæcal appendiceal abscess or even psoas abscess. The history and urological examination will usually establish by elimination the perirenal nature of the suppuration.

Laboratory investigations are sometimes of considerable help, especially when urinalysis reveals infection or the blood count shows leucocytosis. It should be remembered, however, that the discovery of a urinary infection does not necessarily establish renal infection as primary to the perirenal process; it may be a secondary development. Pyuria was demonstrated in three-fourths of our patients, albuminuria in half, and 6 were proved diabetics. This latter point is of considerable importance since in 3 diabetics the perinephritic abscess was only one of a number of systemic staphylococcus abscesses.

Leucocytosis is seldom lacking. In half of the cases in which leucocyte counts were made (68) the white cell count was between 15,000 and 25,000; the highest was 38,500. In one fatal case, a leucopenia of 5,500 cells with 65 per cent polymorphonuclears was found; this was one of 5 patients with a total white cell count of less than 10,000 (Table VII).

As shown in Table VIII blood chemistry rarely disclosed marked nitrogenous retention. Unless the opposite kidney is seriously im-

paired, or absent, nitrogen excretion will usually be satisfactorily carried on. Two cases emphasize this; one patient, previously nephrectomized, developed an extensive perirenal abscess of the remaining kidney. The other patient had an infantile kidney on the good side. Both died of uræmia with high blood nitrogen.

Blood cultures showed a systemic infection in 9 of 20 cases thus examined (Table VIII). As one would expect, staphylococci were most often found (6).

Roentgenography may be of great value in establishing the diagnosis. First mentioned by Alexander and described subsequently, simultaneously, and independently by Beer and Lipsett, the frequent disappearance of the psoas muscle shadow on the involved side together with lordosis away from the inflammation is an important diagnostic sign (Fig. 2). On the Urological Service at Bellevue Hospital these criteria have been employed for the past 10 years that I know of. Diagnostically, lumbar lordosis is the more valuable of the two signs since other lesions than perirenal abscess may cause psoas muscle outline obliteration. Lordosis, however, appears later than psoas obliteration. It is due to erector spinæ and psoas spasm of the involved side. In half (24) of the 46 cases in this series subjected to X-ray examination, the procedure was diagnostically unproductive (Table VII).

Roentgenography is of further valuable assistance in the demonstration of complicating secondary subphrenic abscess. While definite physical signs of this condition are usually present, in certain instances, the roentgen film may first indicate the correct diagnosis. Elevation of the diaphragm with partial or complete obliteration of the costophrenic sinus are the skiagraphic diagnostic criteria. On fluoroscopy, limitation of phrenic excursions or actual diaphragmatic immobilization may be visualized.

Cystoscopy with ureteral catheterization, renal function tests, and pyelography may be resorted to when the diagnosis is obscured, but in the anticipation of this procedure it should be borne in mind that perhaps no help will be obtained. Renal infection or diminished function may be demonstrated; pyelography may reveal a kidney or ureter displaced (Fig. 3) or compressed by the perirenal mass or may show evidence of the probable intrarenal origin of the abscess (pyonephrosis, stone, tumor, trauma, pyelonephritis). However, in only 14 of the 33 cases in this series subjected to complete urological examination was diagnostic help thereby obtained and what is perhaps more important, in 2 cases the examination findings actually confused the diagnosis (Table VII). The renal pathology was demonstrated on the side without perirenal involvement. Therefore, in some instances lacking a clear diagnosis, loin exploration must be resorted to. Loin exploration with an aspirating needle may be performed but is an unreliable guide. Surgical incision is preferable.

The 26 cases of this series which came to autopsy with undiagnosed perirenal abscess form a most instructive group demonstrating the difficulty of correct diagnosis when symptoms are few or indistinct or when the local signs are overshadowed by those of another grave local or systemic disease. Six of these patients came to autopsy from the medical wards where they had been treated from 4 days to 4 weeks for acute gastro-enteritis (2), diabetes (2), influenza, and chronic myocarditis. The autopsy findings are of note.

One patient in whom the predominant symptoms had been those of acute gastro-enteritis (diagnosed food poisoning) showed besides the extensive perirenal suppuration, a subphrenic abscess which had penetrated the diaphragm and caused terminal pneumonia with empyema. The other, a tabetic with clinical gastro-enteritis, had a secondary peritonitis and empyema due to perirenal abscess extension. Both diabetics died with high fever and sepsis; the perirenal suppuration was unsuspected. Shortness of breath and general toxæmia were the chief symptoms of the "influenza" patient; autopsy disclosed an unrecognized acute suppurative appendicitis as the primary disease leading to extensive perirenal abscess. It is noteworthy in this connection that in a great many cases the toxic systemic symptoms due to the perirenal pus cause the diagnosis of influenza to be made. Finally, the patient treated for

myocarditis with œdema showed a moderate left pyonephrosis due to stone with a massive secondary perirenal abscess. The remainder of the autopsy cases were from other services in the hospital and included two from the Urological Department. In one, the unrecognized perirenal lesion was secondary to prostatic abscess and in the other, to impacted stone pyonephrosis.

The findings noted have been uncritically detailed to emphasize the clinical difficulties encountered in the recognition of perinephritic abscess particularly in extremely ill patients. The diagnostic errors of omission and commission in this entire series of 83 cases were made for the most part by outstanding clinicians of New York City and indicate that in the hands of the less experienced general practitioner, perinephritic abscess will be even less often correctly diagnosed.

TREATMENT

Liberal incision and drainage constitutes the treatment of perirenal abscess. Great care must be exercised that all pus pockets are opened; having failed to do this in two cases, re-exploration was necessitated. Suppuration on the anterior renal surface in particular should be well drained since secondary intraperitoneal infections from this source sometimes occur. Two-thirds (54) of our cases were operated upon. One patient having a definite clinical and skiagraphic diagnosis of perirenal abscess showed such marked improvement during brief hospitalization that he was discharged without operation. Two others refused operation and in 26 cases the lesion was discovered at autopsy.

Local anæsthesia may be used advantageously when the patient is extremely sick and little exploration is required (bulging loin). Often the establishment of a loin drainage hole is sufficient to preserve life and allow a more extensive investigation at a later date. This was done in 4 of our cases. In two instances, spinal anæsthesia was used with satisfaction but the majority (48) were given gas-oxygen-ether. The initial operation in all was incision with perirenal drainage.

Eleven of the 54 operative patients died, a mortality of 20.4 per cent. Most of these patients died of complicating lesions or operations other than of perinephritic abscess itself. Thirteen required additional operations; 4 of which were transfusions. Twice secondary perirenal exploration was carried out. In two instances nephrectomy for pyonephrosis was necessary and nephrotomy for drainage was done once. In one case secondary femoral thrombosis required leg amputation and twice complicating abscess demanded prostatotomy.

Without attempting a detailed résumé of the various complications encountered in this series, it should be emphasized that most are pulmonary or urological (Table IX). Pneumonia and empyema are frequently caused by subphrenic suppurative extension. In one case thrombosis of the renal vessels with massive renal thrombosis quite evidently resulted from perirenal suppuration encircling the pedicle. One patient studied 2 years following incision and drainage for abscess showed a tight ureteral stricture in the region of the previous suppuration. We assume this to be the result of perirenal sclerosis.

Suppurative processes in the genital tract were found in 11 cases (15 per cent of the male patients) and required appropriate treatment. One patient showed a fatal generalized postoperative staphylococcus lymphangitis of the loin and back extending from the scapular spine to the iliac crest. Another suffered nonoperative paralytic ileus, a symptom said by some to be a rather frequent complication of perirenal abscess and induced reflexly by retroperitoneal irritation. Associated metastatic suppuration was found in 7 of our cases; drainage is the treatment.

SUMMARY

A clinical study of 83 cases of perinephritic abscess is reported. Etiologically the disease is of extrarenal or intrarenal origin and in the majority of cases bacterial metastasis is the mechanism. While the predominant symptoms are fever, loin or costovertebral angle pain, leucocytosis, and reflex urinary frequency, disease other than perirenal abscess may be suggested both subjectively and objectively. With this confusion of symptoms and ofttimes meager or indefinite clinical findings, the diagnosis is difficult. In a third of

this series, the diagnosis was made only at autopsy.

Stereoscopic roentgenography is of special value when it shows obliteration of the psoas muscle margin on the side of the abscess or lateral spinal curvature away from the abscess. Moreover, when complicating subphrenic abscess is present, elevation and fixation of the diaphragmatic dome with costophrenic sinus obliteration is diagnostic. Technical urological examination may be of no aid and as we have twice seen may actually confuse the diagnosis.

The treatment is surgical drainage although rarely a patient recovers without operation. Complications are of frequent incidence and involve the pulmonary and genito-urinary systems in particular. In our series of 54 cases operated upon for perirenal abscess, 11 died, an operative mortality of 20.4 per cent. It is noteworthy that most of these fatalities were directly due to complications and the surgical treatment thereof rather than to the primary abscess.

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PRIMARY CARCINOMA OF THE FALLOPIAN TUBES[1]

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CARCINOMA of the fallopian tubes is classified as either primary or secondary. Although both conditions have been considered rare and relatively uncommon, even now primary carcinoma is the most common tumor of the fallopian tubes. The purpose of this paper is to show chiefly that: (1) there is a gradual increase in the number of cases of primary carcinoma of the fallopian tubes; (2) the inflammatory changes in the fallopian tubes do not deserve the etiological significance attributed to them by many writers; and (3) the proper diagnosis of carcinoma of the fallopian tubes can be arrived at only by macroscopic and microscopic examination. Earlier writers recognized the existence of malignant tumors of the oviduct, but they failed to make a distinction between the primary and secondary growths. Renaud, in 1847, reported a case of a malignant growth of the fallopian tube and described the macroscopic appearance of the growth. The plate of this first case on record indicates that the growth was probably primary in origin. Orthmann, as early as 1888, with his case gave the first reliable description of primary carcinoma in the tubes. The third case of carcinoma of the tubes was reported by Doran, in 1888, the fourth by Kaltenback, in 1889, the fifth by Routier, in 1893, and the sixth by Tuffier, in 1894.

Among the earliest and most notable authorities on the subject were Sanger and Barth, who gave such complete detailed and comprehensive descriptions of the primary growth that their classification of this lesion has remained standard. They reported a group of 17 cases of primary epitheliomata and several tumors of connective tissues. Additional cases of equal value and merit were published by Osterloh, in 1896, and by Ries, in 1897. Then Duret, in 1899, reviewed 35 cases, of which 29 were epitheliomata, 5 were sarcomata, and 1 was a malignant deciduoma. Quénu and Longuet, in 1901, reported 36 cases, with a pathological description and a review of the opinions in all former reviews of the subject. Peham, in 1903, reviewed 62 cases, in 3 of which the condition was bilateral.

Beginning about 1904 and continuing to the present time, an increasing number of cases has been reported. Doran, in 1904, reviewed 63 cases; Orthmann, in 1906, brought the total up to 84. Then Doran, in 1910, again published 100 cases of primary carcinoma, the greatest number of cases which had been reported, although Anduze-Acher very soon reported 115. Vest, in 1914, reported 132 cases, and Moench and Schaerer, in the same year, added 21, making 153 cases. Wechsler, in 1926, after a thorough review, reported on 196 cases, including 4 of his own with 2 of Liang's; 1 by Callahan, in 1929, along with 9 in this paper, now make a total of 206 cases of primary carcinomata of the fallopian tube. Obviously the recognition of carcinoma of the fallopian tubes has increased along with the improved technique and more comprehensive knowledge of microscopic anatomy of tissues.

Following the recognition and acknowledgment of the comparative frequency of carcinoma of the fallopian tube came various opinions and explanations of its cause. Among the most outstanding theories was that of Doran and Fearne, who were of the opinion that primary carcinoma of the tube developed from malignant degeneration of benign papillomata, frequently found in cases of catarrhal and suppurative inflammation. Sanger and Barth, on the other hand, assumed that primary carcinoma develops from long standing, chronic salpingitis. They contended that a papillomatous intermediary stage was unnecessary. In recent years, however, Eckardt and Friedenheim did not find any evidence of inflammatory changes that might safely be regarded as the cause of malignant transformation. They maintained that the inflammatory changes found might

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be the result of, rather than the cause of, the malignant process, especially in those cases in which the growth had infiltrated as far as the serosa. Then too, Eckardt's argument must be taken into consideration, for he claimed that if inflammation were a predisposing factor, more bilateral carcinomata would be found. After thoroughly searching the literature, only 69 cases of bilateral carcinoma were found in a total of 206 cases. Stolz agreed with Eckardt in his opinion that the chronic inflammatory condition of the tube does not warrant the etiological significance attributed to it by Sanger and Barth. It is possible that inflammation may be a predisposing factor in carcinomatous growth of the tubes, but it is just as possible that carcinoma may develop from non-inflamed tubal mucosa.

The rather universal theory, first stated by Horrock, that carcinomata are more common in sterile women has often been refuted. For example, Sanger and Barth found only 50 per cent of sterile women in their series, and Stolz, in a series of 17 cases, found only 6 women that had not borne children. In 206 cases reported, 101 women were found to have borne one child or more. Moreover, 48 of the 206 women were sterile; 45 could not be classified, as information was lacking; 13 had miscarried or aborted, and 1 woman was a virgin. Of the 101 who had borne children, 43 were uniparous. The history of pelvic infection was given in only a few cases, but it was noted that 114 women had conceived. Unilateral or bilateral salpingitis was insufficient to prevent conception or the patients were free from infection. Relative to the 43 women who had only 1 child, infection following delivery was a point of consideration. Among the 58 remaining cases, statistics showed that the women had borne 5, 7, 9, and 10 children. Because of the inadequate history of pelvic infection and lack of examination of the husband it was quite impossible to determine the cause of sterility in the 48 cases. Stolz has likewise shown that sterility is not more common in women with carcinoma of the fallopian tube than in women with other pelvic tumors. Quénu is of the opinion that chronic salpingitis is only a secondary factor in a large proportion of cases, and that every neoplasm with papillary growth on the surface becomes infected sooner or later. From these statistics certainly it cannot rightly be concluded or deducted that carcinoma of the fallopian tubes is usually associated with sterility. Likewise, just as few substantiate von Franqué's theory that tuberculosis is an etiological factor in predisposing to primary carcinoma of the fallopian tube.

In a review of the cases from the files in The Mayo Clinic during the period of 1910 to 1928, I was able to find only 9 cases of primary carcinoma of the fallopian tubes, in a series of approximately 10,000 completely removed tubes. Seven of the carcinomata occurred in one tube only; two were bilateral. In other words, eleven primary carcinomata were found in approximately 10,000 tubes, or an incidence of 0.11 per cent. The carcinomatous growth involved the right tube in 3 cases, and the left tube in 4 cases. In the series of about 10,000 tubes, 81 tubes showed definite signs of carcinomatous growth, 70 of which were considered to be secondary in origin, either by contiguity or metastasis. So far as could be determined, 62 were secondary to carcinoma of the ovary, whereas 8 were secondary to carcinoma of the uterus. Norris reported only 1 primary carcinoma and 8 secondary carcinomata of the tube in more than 2,000 gynecological specimens. He also reported 62 carcinomata of the cervix and 32 malignant lesions of the fundus. Novak, stated that at Johns Hopkins Hospital up to December 31, 1927, they had observed approximately 12,000 tubes, and of this number 5 were found to contain primary carcinoma, an incidence of 0.04 per cent. Such statistics certainly do not indicate that inflammation plays such a significant part in the development of carcinoma of the fallopian tube as has been supposed by some writers.

As regards the age incidence, my review shows that in 189 cases in which the age was given, the condition occurred between the ages of 40 and 50 years in 90 patients (47 per cent). According to Mantel, the oldest patient on record was aged 73 years; the youngest patient so far on record (case 3 of

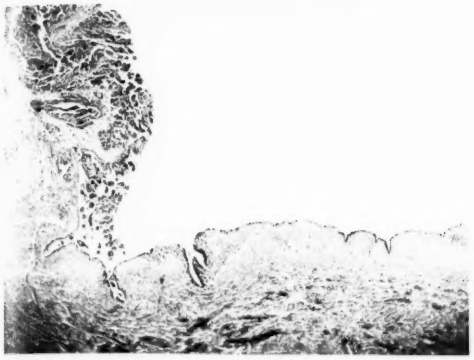

Fig. 1. Transition of normal mucous membrane into malignant tissue showing attachment of a malignant papilloma at the left with invasion of deeper structures of the tube. Case 2. ×40.

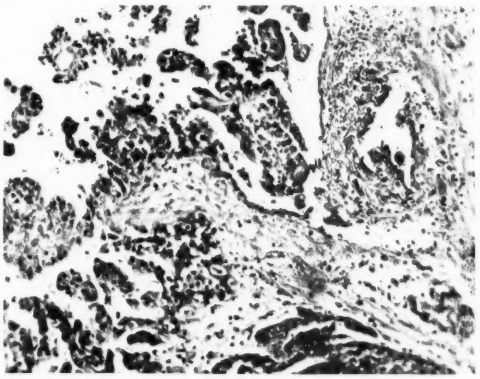

Fig. 2. Area of malignant papilloma showing reduplication of cells and increased chromatin content with vacuolization. Case 2. ×75.

this series) was aged 26 years. The following data are in accord with the observations of Sanger and Barth, both of whom pointed out that the age incidence among patients with carcinoma of the fallopian tubes is greatest about the climacteric. The age of the patient was from 25 to 30 years in 4 cases, 30 to 35 in 6, 35 to 40 in 24 (13 per cent), 40 to 45 in 44 (23 per cent), 45 to 50 in 46 (24 per cent), 50 to 55 in 35 (18 per cent), 55 to 60 in 23 (12 per cent), 60 to 65 in 5, 65 to 70 in 1, and 70 to 75 in 1 case.

Sanger and Barth, in 1895, reviewed a series of 18 cases, and after an exhaustive study published a detailed description of the histological pathology of the primary growth. Their classification is still retained and is regarded as authoritative by most writers. They classified the malignant growths as carcinoma of purely papillary structure, and carcinomata of papillary alveolar structure. Another classification frequently referred to is that of Friedenheim's who classified the growths of the carcinomata of the mucous membrane which include papillary and alveolar types, and carcinomata of the wall of the alveolar type.

PAPILLARY TYPE OF CARCINOMA

The histological picture of this type of growth shows a delicate connective stem covered with epithelium in a single layer or more, reduplication of the epithelium being the rule rather than the exception. Usually both forms, the papillary and papillary alveolar, are found in the same section, especially if the growth has penetrated the wall of the tube. The cells vary in size, shape, and staining properties. In the lumen

Fig. 3. Area of right tube showing tubercle with giant cell and alveolar carcinoma with acinous formation; densely staining cells; few mitotic figures. Case 3. ×320.

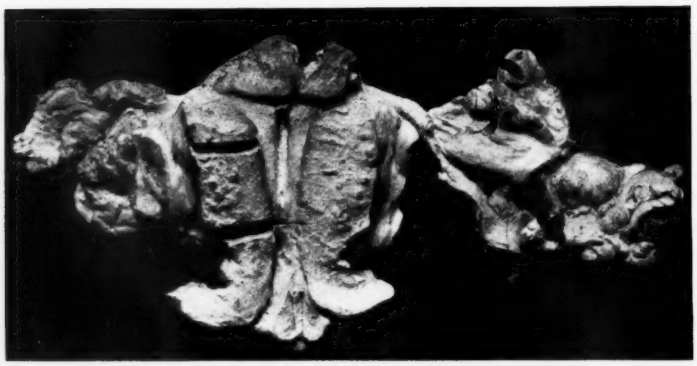

Fig. 4. Papillary carcinoma of fimbriæ of the left tube and carcinoma of the left ovary. Case 6.

of the tube, however, the normal cylindric cell is more or less preserved. The cells show large nuclei and increase in the content of chromatin, together with a change in polarity. The connective tissue stroma is usually infiltrated with small round cells. As the growth invades the deeper structures, a zone of reaction occurs which consists of fibrous tissue with small round cells and hyalinization according to the reaction of the tissues and rapidity of the growth, as pointed out by MacCarty in 1925.

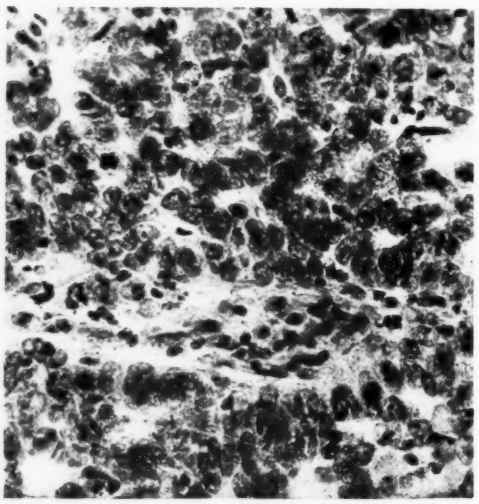

Fig. 5. Section from wall of tube, showing highly malignant cells arranged in pseudo-alveolar formation. Case 6. ×320.

PAPILLARY ALVEOLAR FORMS

In papillary alveolar forms, the alveoli and pseudo-alveoli may be found in the lumen of the tube from apparent fusion of the many papillary projections. The papillary alveolar constructions, however, are usually found in the deeper structures of the tube. Definite solid columns of cells and also alveoli are found between the muscle fibers and beneath the serosa.

The macroscopic examination of the tubes presents a change in shape and size according to the degree of involvement. They are usually club-shaped and have the appearance of chronic pyosalpingitis or hydrosalpingitis covered with numerous adhesions. In some instances carcinomatous nodules often appear beneath the serosa.

Kleinhaus pointed out that squamous cell epithelioma of the tube through metaplasia of the cylindric epithelial lining may be present. L'Esperance described a carcinoma of the tube with zones resembling the skin. Barrett, in 1916, found keratinized tumor cells with some epithelial pearls. Case 9 of this series illustrates squamous cell epithelioma involving the fimbriated end of the left tube with metastasis to the right ovarian wall of the cyst. In each case a definite palisading and pearly body formation was found.

When these specimens were excised a gray or grayish yellow, irregular, vascular, and friable mass was usually seen. Sometimes the walls were lined with a flat papillary growth

and the lumen contained dark fluid. Because of the obscurity of some of these growths, differentiation of the normal and the pathological specimen by inspection and palpation alone was difficult, as is illustrated in Case 9 in this series, in which a small area of squamous cell carcinoma was noted in the fimbriated end of an apparently normal tube.

A total of 8 cases in which tuberculosis and primary carcinoma of the tubes were associated have been reported by von Franqué, Lipschitz, Barrett, L'Esperance, Stuebler, Wechsler, and Callahan, Schiltz and Hellwig. A tuberculoma of one tube and a carcinoma of the other were reported by Montgomery. Stacy and Melson, in 1923, reported a case of adenocarcinoma of the ovary and the tube associated with tuberculosis in which the origin of the lesion was doubtful. Case 3 of this series clearly demonstrated bilateral carcinoma and tuberculous salpingitis. The tubercles with giant cells and tubercles with malignant cells occurred in the same field. Case 8 is an example of papillary carcinoma of the left tube and tuberculosis of the right tube.

REPORT OF CASES

CASE 1. A woman, aged 44 years, was admitted to The Mayo Clinic June 11, 1914. Menses had begun at the age of 19 and were always irregular and painful. She had never been pregnant. In 1903, a small tumor had been removed from the vagina. Appendectomy had been performed in 1910. Three weeks before admission to the clinic, pain had developed in the right lower quadrant of the abdomen. The pain occurred half an hour after meals; it was not referred, and was relieved by enemas. The patient had lost 9 pounds in the last 3 weeks.

The uterus was enlarged and retroverted. A small, fibrous tumor in the left side and a mass in the right fornix were palpated. Urinalysis was negative. The hæmoglobin was 89 per cent. The pre-operative diagnosis was questionable and exploration was advised.

Total abdominal hysterectomy and bilateral salpingo-oophorectomy was performed, June 16. Myoma of the uterus, double pyosalpinx and cystic ovaries were found. The right broad ligament appeared to be malignant.

The pathologist reported that on gross examination the ovaries showed chronic cystic oophoritis, chronic salpingitis of the left tube, and a carcinoma of the right tube involving the outer two-thirds. The abdominal ostium was closed. The tube was retort-shaped with many adhesions. The wall

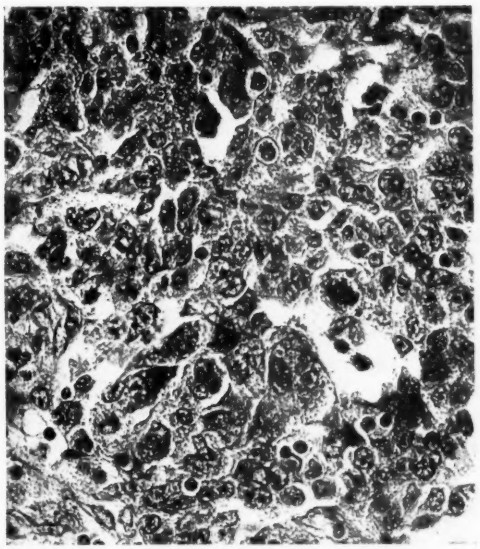

Fig. 6. Section from wall of left tube, showing irregular malignant cells, with mitotic figures. Case 7. ×320.

was thin and was distended with a friable gray mass and purulent fluid. The uterus was enlarged and contained multiple myomata. Microscopic examination, on section through the center of the growth, showed a papillomatous mass that was undergoing necrosis and a few mitotic figures with the growth extending into the muscle and subserosal areas, forming true and false acini of papillary and alveolar carcinoma, graded 2.

CASE 2. A woman, aged 52 years, was admitted to the clinic August 5, 1920. She had 4 children, the youngest of which was aged 21 years. Her mother had died of tumor. The patient's menses had been regular and the menopause had occurred at the age of 43 years. Appendectomy had been performed in 1911. May 5, 1920, the patient had had profuse and painless free hæmorrhage from the vagina. Bleeding had occurred daily since, which had been malodorous for 1 month. The patient had had pain in the lumbar region for 2 weeks before admission to the clinic. She had lost 12 pounds in weight in the last 9 months.

The fundus of the uterus was in the anterior position, the cervix was smooth and not fixed, and a slight reddish discharge was observed. Urinalysis showed albumin, graded 2, and erythrocytes graded 4. The hæmoglobin was 79 per cent; erythrocytes numbered 5,020,000 and leucocytes 6,400. The pre-operative diagnosis was carcinoma of the fundus of the uterus.

Total abdominal hysterectomy, bilateral salpingectomy, and right oophorectomy were performed August 17. The left ovary was missing. The uterus

Fig. 7. Two nodules of squamous cell epithelioma at fimbriated end of left tube and two metastatic nodules in wall of right ovarian cyst. Case 9.

was normal and the tubes were large, adherent, and hæmorrhagic. A malignant condition was suspected in the left tube. The right ovary was small and soft. The appendix was removed. The gall bladder was normal but adherent.

The pathologist reported that gross examination of the uterus revealed atresia of the internal os, cystic cervicitis, and hæmatosalpinx of the right tube, which weighed 62 grams. The left tube was distended with blood stained fluid, and the inner surface was covered with papillary growths. The right ovary was atrophic. Microscopic examination, on section near the fimbriæ, showed the mucous membrane to be normal; low columnar epithelium could be traced to the origin of malignant papilloma (Figs. 1 and 2). The cells were spherical and there were many mitotic figures, and definite invasion of the muscular layer beneath the site of the carcinoma, which was of the papillary type, graded 3.

CASE 3. A woman, aged 26 years, was admitted to the clinic October 30, 1913. She had never been pregnant. Dysmenorrhœa and irregular menses had been present for 2 years. Metrorrhagia or menorrhagia was not present. Tonsillectomy had been performed 4 months previously. For 4 months the patient had suffered from generalized abdominal soreness and bloating, which had disappeared except for pains in the bladder at night and backache. For the last 3 days a burning sensation in the epigastrium had been noted. There had been no loss of weight. Examination revealed that the pelvis and cervix were normal. There was a tumor to the left which seemed closely connected with the fundus and which was slightly tender. The pre-operative diagnosis was a fibrous tumor in the uterus. Bilateral salpingectomy, complete oophorectomy on the left, almost complete oophorectomy on the right, and appendectomy were performed November 11. The pelvis was filled with granular material that resembled tuberculous material.

The pathologist reported that on gross section the tubes were tortuous, dilated, and bound down together, with the ovary adherent, carcinoma of both tubes, chronic cystic oophoritis, and chronic catarrhal appendicitis. Microscopic examination, on section of both tubes, showed areas of malignant cells and tubercles with giant cells in the same field. The right tube contained an alveolar carcinoma graded 2 (Fig. 3); the left tube contained a papillary carcinoma, graded 3.

CASE 4. A woman, aged 57 years, was admitted to the clinic May 26, 1921. An aunt had died of carcinoma. The patient's menses had been normal; the menopause had occurred at the age of 49 years. She had never been pregnant. A small tumor had been removed from the vagina in 1904. Profuse metrorrhagia had been present from July, 1920, until a few weeks prior to the patient's entrance to the clinic, at which time a yellow discharge was present which was not associated with pain. The patient had had lumbago 15 years prior to this. She had lost 10 pounds in weight during the previous year. Her temperature was 99.4 degrees F.

The uterus was small, anteflexed, and movable. Urinalysis and the Wassermann reaction of the blood were negative. Erythrocytes numbered 4,120,000 and the hæmoglobin was 67 per cent. Leucocytes numbered 9,900; polymorphonuclear leucocytes comprised 27 per cent, lymphocytes 35 per cent, eosinophiles, 30 per cent, and basophiles 8 per cent. The pre-operative diagnosis was carcinoma of the fundus of the uterus.

Fig. 8. Section of nodule from fimbriæ of left tube, showing densely stained cells with many mitotic figures. Case 9. ×320.

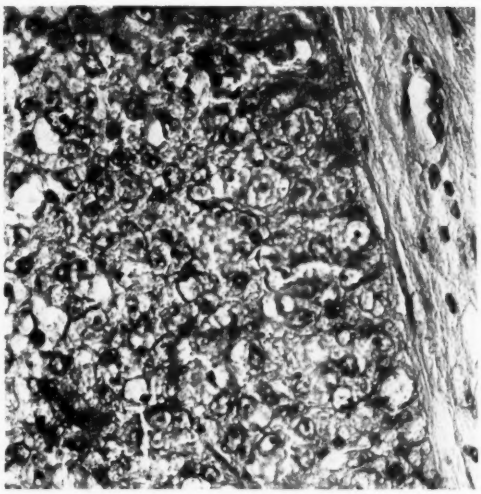

Fig. 9. Section of metastatic nodule of wall of right ovarian cyst which shows the same type of cells as in Figure 8. Case 9. ×320.

Subtotal hysterectomy and removal of both tubes and ovaries were performed June 2. The left tube measured 8 by 4 by 4 centimeters and appeared to be malignant. The appendix was removed secondarily. The gall bladder contained stones. The uterus contained one fibroma.

The pathologist reported that gross examination revealed a uterus of the infantile type with multiple fibromata, atrophic endometritis, hydrohæmatosalpinx of the left tube distended at the fimbriated end with papillary growth, hæmatosalpinx of the right tube, atrophic ovaries, and chronic appendicitis with obliteration of the distal two-thirds of the tip. Microscopic examination, on section from the fimbriæ, showed malignant papilloma invading the muscle wall. There were spherical cells, prominent nuclei, and many mitotic figures. The diagnosis was papillary carcinoma, graded 3.

CASE 5. A woman, aged 65 years, was admitted to the clinic March 22, 1915. She had had two children. The menstrual history was normal and the menopause had occurred at the age of 50. Cholecystectomy had been performed in the clinic December 6, 1910.

The right kidney was palpable; a pelvic mass extended halfway to the umbilicus. Urinalysis showed a trace of albumin, granular casts, and a few erythrocytes. The hæmoglobin was 82 per cent. The pre-operative diagnosis was questionable and exploration was advised.

Supravaginal hysterectomy with removal of both tubes and ovaries was performed April 25, 1915. The right ovary contained a malignant cyst, the size of a pregnant uterus at term. The left ovary and tube were inflammatory. The appendix was adherent to the tumor. The cyst ruptured during removal.

The pathologist reported that gross examination revealed a uterus of the infantile type, and a right tubo-ovarian cyst, an intracystic papillary carcinoma which was attached to the tubal site of the cyst, left chronic salpingitis and left cystic oophoritis. Microscopic examination revealed that the structure of the right tube was replaced by a homogeneous mass composed of spherical densely staining cells which contained many mitotic figures. In the center of the homogeneous mass were several large alveoli lined with large fusiform cells with fasicular nuclei. The carcinoma was of the papillary alveolar type, graded 4.

CASE 6. A woman, aged 52 years, was admitted to the clinic September 21, 1921. She had had 4 children and 1 miscarriage. Her mother had died from cancer of the breast, and a sister had died from cancer of the uterus. The menopause had occurred at the age of 50 years. The patient had been at the clinic in 1916 and had a small mole on the back removed, at which time the pelvis was normal except for a cystocele, graded 2. A sanguineous discharge had been present since July, 1921.

General examination showed enlargement of the thyroid gland. The cervix of the uterus was slightly inflamed, without erosion or induration; the fundus was small and free. Urinalysis of a catheterized specimen showed a trace of albumin and pus graded 5. The hæmoglobin was 72 per cent.

Total abdominal hysterectomy and bilateral salpingo-oophorectomy were performed September 23, with removal of a nodule from the cæ-

cum for diagnosis. A carcinoma, evidently primary, was found in the left tube. The appendix was removed secondarily. There were several carcinomatous nodules in the omentum.

The pathologist reported that gross examination revealed an atrophic endometrium, the right tube was atrophic, and the left contained a carcinoma, 5 by 3 by 3 centimeters (Fig. 4). The right ovary was atrophic and the left contained a carcinoma 1.5 by 1 centimeter. The appendix had a secondary carcinoma at the tip, and the cæcum a papillary carcinoma of the serosa. Both these carcinomata had the same histological structure. The ovarian carcinoma had not broken through the serosa. There was no demonstrable connection between the two; therefore it is reasonable to conclude that they were separate growths. Microscopic examination showed that the lumen was filled with papillary carcinoma, with a few strands of connective tissue converging through the homogeneous mass (Fig. 5). There were densely staining cells with many mitotic figures. The diagnosis was papillary alveolar carcinoma, graded 3.

CASE 7. A woman, aged 44 years, was admitted to the clinic May 14, 1914. Her mother had died of carcinoma of the uterus. The patient's menses were normal until 6 months prior to examination, when menorrhagia occurred, the last period being in March. She had had one child. Appendectomy had been performed in 1912. She now entered the clinic because of vague abdominal pains and nausea but the general examination was negative. The patient returned to the clinic May 17, 1915. Amenorrhœa had been present for 6 months and dull pain in the pelvis with a mass had been noted.

There was a cyst on the anterior lip of the cervix and the uterus was retroflexed; there was a mass behind the fundus. The pre-operative diagnosis was questionable and operation was advised.

Bilateral salpingo-oophorectomy for chronic pelvic inflammatory disease was performed, May 28. The left tube was adherent to the sigmoid. Gall stones were present. Cholecystectomy was performed August 12, and a single stone was found obstructing the common bile duct. Pancreatitis, graded 1, was present.

The pathologist reported that gross examination revealed chronic salpingitis on the right, chronic oophoritis, and a distorted and enlarged left tube, the lumen being filled with papillomatous growth that extended from the fimbriæ to the uterine end, with thick walls and shaggy serosa. Microscopic examination showed strands of malignant cells that could be traced to subserosal areas, large cells, loosely grouped chromatin granules in the cytoplasm with prominent nucleoli, and many mitotic figures (Fig. 6). The diagnosis was papillary carcinoma, graded 4.

CASE 8. A woman, aged 48 years, entered the clinic June 12, 1911. She had never been pregnant. She had been at the clinic in 1905, at which time a small fibrous tumor was removed. Two months prior to admission, severe abdominal colic developed which lasted for several hours; one week prior to admission nausea and vomiting, with colic, occurred which lasted 3 days. The abdomen had been enlarging for 3 months. There had been no loss of weight.

The temperature was 99 degrees F. A questionable mass was present in the abdomen. Fluid was not present. A fibrous mass filled the pelvis. The pre-operative diagnosis was fibroma of the uterus.

Subtotal abdominal hysterectomy was performed June 27, which revealed multiple fibromata and a carcinoma of the left tube which formed a tumor about 8 centimeters in diameter.

The pathologist reported that gross examination showed a small uterine polyp, symmetric dilatation of the outer two-thirds of the right tube, enlargement of the left tube, the entire length with dilatation into a large cyst lined with flat papillary growths at the fimbriæ, and cystic ovary. Microscopic examination, on section of the left tube, showed small papillomata arising from the wall of the cyst, reduplication of cells with prominent nuclei, absence of polarity, invasion into the muscle wall, the border of which was marked by small round cells and hyalinization, and a few mitotic figures; the diagnosis was papillary carcinoma, graded 1. The right tube showed advanced tuberculosis.

CASE 9. A woman, aged 51 years, entered the clinic April 29, 1925, with a complaint of a "bearing down" feeling in the pelvis for 3 months. She had had slight pains in the right side since 1918. She had never been pregnant.

There was slight tenderness over MacBurney's point, and a small mass was palpable above the symphysis. There was bilateral laceration of the cervix; the uterus was in fair position. A pedunculated mass was noted to the right and anterior to the uterus. The pre-operative diagnosis was fibromyoma of the uterus.

A simple cyst, 12 centimeters in diameter, of the right ovary and multiple fibromata of the uterus were removed at operation May 2. The growth at the fimbriated end of the left tube was apparently malignant. The left ovary was found to be normal (Fig. 7).

The pathologist reported that the uterus revealed multiple fibromyomata, hypertrophic endometritis, and cystic cervicitis. The right ovary was multilocular, with two nodules of squamous cell epithelioma in the wall. The left ovary had chronic cystic oophoritis. The left tube contained squamous-cell epithelioma at the fimbriæ; chronic salpingitis was present in the right tube. Chronic appendicitis with obliteration of the lumen was noted. Microscopic examination of a section from the fimbria of the left tube revealed a squamous cell epithelioma graded 3, with the formation of pearly bodies, prominent nucleoli and many mitotic figures (Fig. 8). Section from a nodule of the right wall of the right ovarian cyst showed the same type of cells (Fig. 9).

CONCLUSIONS

1. Carcinoma of the fallopian tube is not as rare as was formerly believed.

2. Inflammatory changes in the fallopian tubes do not deserve the etiological significance relative to carcinoma attributed to them by many writers.

3. The proper diagnosis of carcinoma of the fallopian tube can be arrived at only by macroscopic and microscopic examination.

4. From sections examined it would seem that papillary alveolar and alveolar types are advanced stages of primary papillary malignancy.

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CLINICAL SURGERY

FROM THE LAHEY CLINIC

TWO-STAGE ABDOMINOPERINEAL REMOVAL OF CANCER OF THE RECTUM

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THE plan of procedure to be described has been worked out in this clinic to meet what to us seem certain defects in already existing operative schemes in the two-stage abdominoperineal management of cancer of the rectum. The plan is presented with no idea that it should be the sole or is the best plan of two-stage management of these serious risk operative cases. The defects of other procedures are presented only as they have appeared to us in our experience; we fully realize that the inventors of the plans may not agree with us.

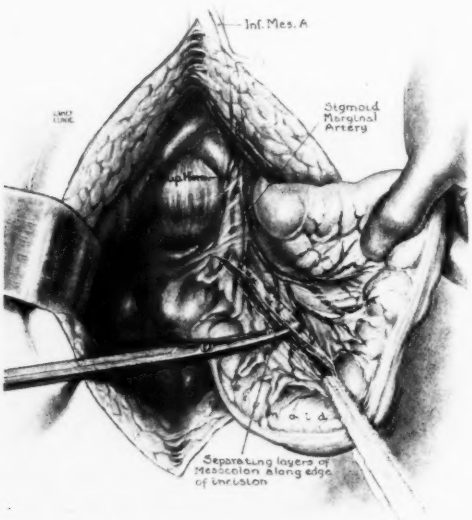


Fig. 1. The median incision, with the sigmoid pulled out onto the left abdominal wall, the mesentery of the sigmoid cut and its vessels ligated from the mesenteric margin of the sigmoid down to, but not including, the superior hæmorrhoidal artery as it descends from over the promontory of the sacrum. The separation of the leaves of mesenteric peritoneum which are later to be sutured together to peritonealize the cut edges of the mesentery is also shown.

As to the originality of the plan, we can only state that we have no knowledge that it has been described elsewhere in the literature or in any of the recent articles on the combined abdominosacral operations for cancer of the rectum. Quite likely this simple plan has already been employed by other men, and an exhaustive search of the French, German, and Italian literature would doubtless reveal this fact. It is not our purpose to make a claim for priority, but to describe and illustrate a method which we hope will prove as useful in the hands of other men as it has in ours.

The steps of our technique may be quite well visualized from Figures 1 to 5. A median incision is made between the pubes and the umbilicus, and the field is investigated for metastases and to determine the operability of the rectal growth. If the growth is operable, the sigmoid is pulled out upon the abdominal wall and the lowest point well above the growth which will reach just above the skin level of the abdominal wall at the pubic end of the abdominal portion of the wound is noted. The mesenteric peritoneum on either side of the mesentery from the sigmoid down to the promontory of the sacrum is cut (Fig. 1), and all the vessels in the mesentery of the sigmoid from the bowel itself down to the superior hæmorrhoidal vessels, but not including them, are ligated.

Midway between the umbilicus and the left anterior superior spine, a small counter incision is made, through which the permanent colostomy is to emerge. Through this incision, as shown in Figure 2, we pass a long handled Ochsner clamp and grasp the sigmoid or high rectum at the point at which its peritoneum has been cut and the mesenteric vessels ligated. Within the original median incision, another Ochsner clamp is made to grasp the sigmoid just below the first Ochsner clamp, and the bowel between the two is severed with a cautery which also sterilizes both ends of

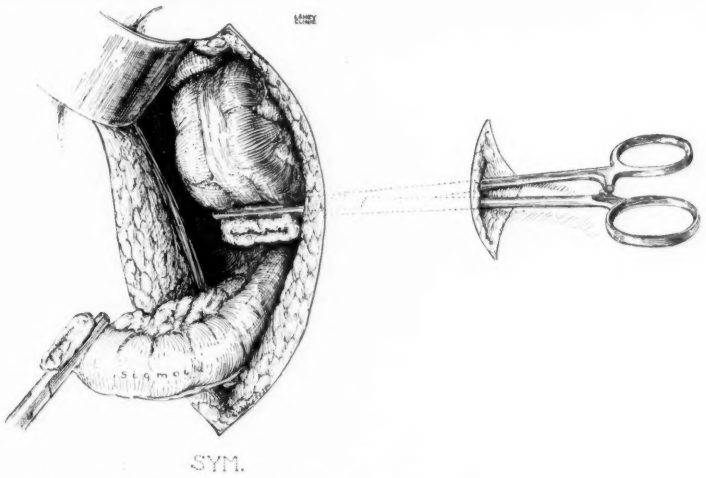


Fig. 2. The sigmoid and its mesentery have been divided in the median incision. A clamp is passed through the left counter incision and grasps the upper loop of sigmoid which is to be drawn out through the left counter incision for the permanent colostomy. The clamp in the median incision on the lower segment of sigmoid which is to be implanted in the lower angle of the wound is also shown.

the bowel. The bowel and its mesentery are thus divided down to the promontory of the sacrum, but the superior hæmorrhoidal vessels remain intact and nourish the lower segment of rectum. The two leaves of mesenteric peritoneum on either side of the divided mesentery of the sigmoid are sutured together with continuous fine catgut to cover the raw surfaces to which small bowel might become adherent during the interval between the first and second operative stages (Fig. 3).

The upper Ochsner clamp and with it the upper segment of sigmoid included in its grasp are withdrawn through the proposed colostomy opening. A few stitches are placed in the parietal peritoneum of the colostomy incision about the colon, also a few in the fascia and skin until the wound fits snugly, but without constriction about the end of the colon. No stitches are placed in the colon itself because we have found that these stitches have occasionally penetrated the bowel and have caused leakage and, later, wound infection. The Ochsner clamp is left in place in the dressing and is not removed until the colostomy is to be opened. It seems to us desirable that this loop of colon should not be too short and too direct to the abdominal wall, but that a considerable loop of bowel be left beneath the colostomy to serve as a fæcal reservoir (Fig. 4).

As is customary in all colostomies, the mesentery of the upper loop of colon serving as a colostomy is now sutured to the parietal peritoneum of the left iliac fossa to prevent herniation and strangulation of the small bowel about the colon going to the colostomy opening.

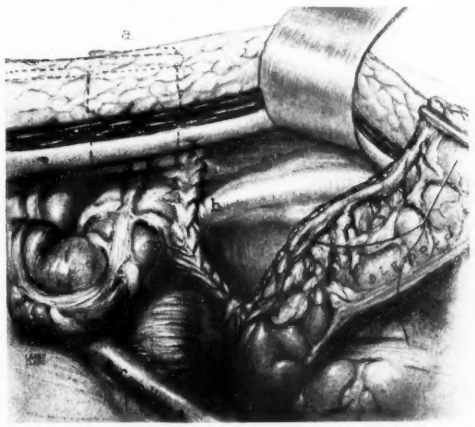


Fig. 3. The two leaves of mesenteric peritoneum are sutured over the cut edges of the mesentery. The upper end of bowel has been pulled through the left colostomy incision, *a* (see Fig. 4), and the mesentery of the upper segment of colon going to colostomy opening has been sutured to parietal peritoneum of left iliac fossa, *b*, to prevent strangulation of small bowel, the lower segment of bowel being placed in lowest point of median incision where it will remain until the second-stage operation.

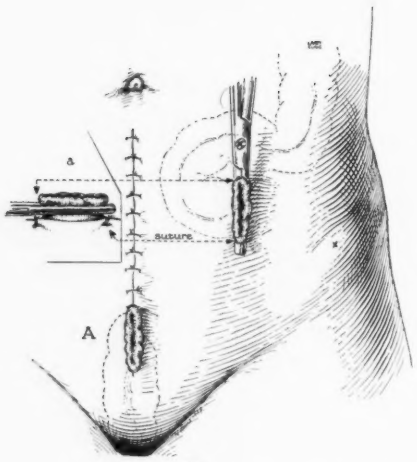


Fig. 4.

Fig. 4. Diagram showing the first stage of the plan we have suggested and employed, completed. The end of the lower segment, *a*, is shown without the Ochsner clamp which remains on it until it drops off. Note the considerable loop of colon which is to serve as a fæcal reservoir shown in outline within the abdominal cavity beneath the left colostomy made by the upper segment of sigmoid. The insert, *a*, shows the plan of approximating skin (and fascia) closely about the end of the transverse colostomy.

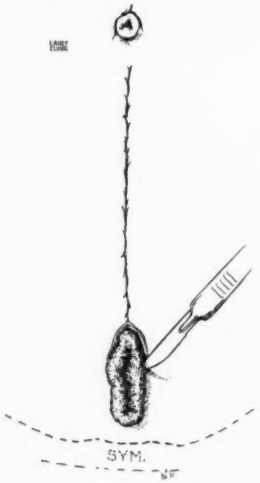


Fig. 5.

Fig. 5. The plan at the second stage of the operation of freeing the end of the lower segment of sigmoid, implanted above the pubes at the first stage, as shown in the previous illustration.

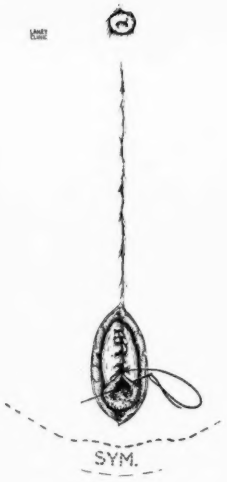


Fig. 6.

Fig. 6. Closure of the end of the lower segment of the sigmoid (second stage), implanted above the pubes preliminary to reopening the abdomen, freeing the pelvic colon and rectum and perineal removal of the freed lower segment in the second-stage operation.

The lower loop with the Ochsner clamp still on it is placed in the lowest point of the median incision just above the pubes and in contact with it, and the wound is sutured in layers about it and throughout its full extent. The abdominal wound is sealed with a cocoon and if it is necessary the colostomy may be opened within a few days, either by tying a tube into it or by surrounding it with sterile boric acid ointment impregnated gauze, by removing the clamp and permitting the wound to drain into a dressing. If it is anticipated that obstruction will make necessary the early opening of the colostomy, it has proved valuable in our experience to pull a considerable segment of colon through the colostomy incision in the abdominal wall. The procedure permits the tying of a large caliber glass tube into the colon and thus prevents wound contamination for several days. The excess of bowel can later be readily removed with the cautery. The clamp usually cuts through the bowel of the lower segment within a week, at which time the median wound is healed so that it is no longer susceptible to infection.

As soon as the clamp is off the lower segment, irrigations are carried out two or three times daily with a rectal speculum in the anus, so that water passes freely from the suprapubic opening in the bowel, along the rectum, and out the anus, thus washing out all fæcal material and irrigating over any ulcerated and infected area. By this time (7 days) the colostomy is working well, and as much time as necessary can now be taken to get the patient into the best possible condition for the second-stage removal, which can usually be undertaken within 2 weeks after this part of the operation.

If further delay is necessary, it can be unhesitatingly accepted, since the bowels move well enough through the colostomy and the lower segment of rectum remains alive and is nourished through the vascularization by the superior hæmorrhoidal vessels and is being cleansed by its irrigations. A few days before the second stage is undertaken, the lower segment of rectum is irrigated several times with S.T. 37 or mercurochrome, in an attempt partly at least to sterilize it.

At the second stage, the colostomy is sealed with a tight cocoon, and the end of the lower segment of bowel which was implanted in the median wound is separated and sutured with silk or chromic catgut (Figs. 5 and 6) in a manner similar to

that described for the suturing of the anus in the perineal removal of the rectum. The stump is painted with iodine. With clean sterile gowns, with a clean kit and clean gloves, the surgeon now reopens the abdomen through the original median incision. An incision in the parietal peritoneum over the superior hæmorrhoidal vessels at the level of the promontory of the sacrum is made and the vessels are tied (Fig. 7). Just as in all abdominosacral operations for cancer of the rectum, the peritoneum on either side of the rectum and in front of it is incised. The ureters are identified and dissected out. The rectum and its mesentery are freed from the hollow of the sacrum down beyond the tip of the coccyx, its lateral and anterior attachment also is freed, and the bowel is pushed down into the pelvis. The diaphragm of the pelvic peritoneum is restored above the rectum, and in the female reinforced by the fundus of the uterus.

The patient is turned on her side. We wish here to stress particularly that in our experience the lateral position for second-stage removal of the rectum produces much less drop in blood pressure than does the position with the patient turned completely onto the abdomen. In many cases the placing of patients, especially obese ones, face down upon an operating table is a dangerous procedure, because of the serious drop in blood pressure often associated with it. The anus is sutured, as is customary in all perineal removals of the rectum, the wound is painted with iodine, fresh instruments and sterile gowns are provided, and the perineal removal is undertaken in the regular manner, the coccyx being detached or not as seems desirable in the case in hand. After the rectum has been removed, a rubber dam, a cigarette drain, or a gauze pack may be inserted in the pelvic cavity as the case demands, depending upon how well oozing has been controlled.

With this description of our plan of procedure before you, we will discuss some of the disadvantages of other procedures as they have appeared to us.

We have always felt dissatisfied with the two-stage Miles procedure[1] (Fig. 8), for the following reasons: If the colon is cut transversely and end colostomy is established either in the upper end of the median wound or in a lateral incision, the colostomy must be established at the time that the pelvic dissection is done. Also in the Miles procedure all of the blood supply of the lower rectum is ligated, and so one has three undesirable factors combined: (1) the production of an unopened colostomy obstruction; (2) a large pelvic dissection with a large area of raw tissue in the pelvis; (3) the placing of a dead segment of bowel filled with infected fæcal material in this undrained pelvic pocket, which is covered above by the restored diaphragm of pelvic peritoneum.

[1]Miles, W. E. Glasgow Med., 1912.

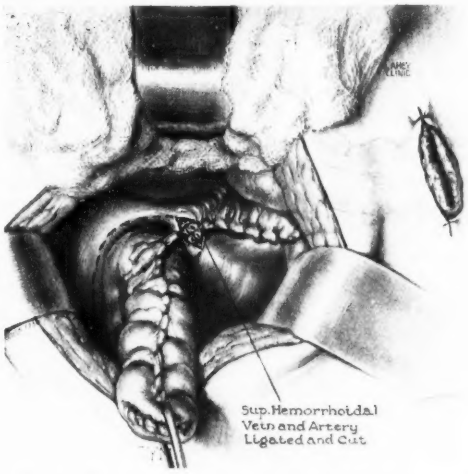
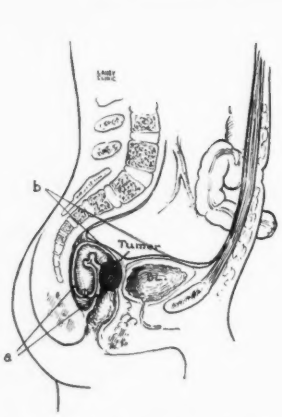


Fig. 7. Showing the abdomen reopened at the second stage. The end of the sigmoid which was implanted above the pubis at the first operation shown in Figure 4 has been sutured as in Figure 6. The parietal peritoneum over the superior hæmorrhoidal vessels has been incised and the superior hæmorrhoidal vessels have been cut and ligated. The dotted lines beside the lower segment indicate the incisions in the pelvic peritoneum prior to separating the rectum from the hollow of the sacrum.

Anyone who has done in this manner second-stage removals of unnourished rectums implanted below the pelvic peritoneum recalls with no pleasure the large amount of accumulated foul fluid which gushes out as soon as the coccyx is removed and the pelvic cavity is approached from behind.

In an effort to evolve measures which would prevent them, we have made a study of the conditions encountered after the first stage of the Miles procedure when we have been forced to do the second stage of the operation because patients were becoming distended, often toxic, and in obviously poor condition. The most undesirable features of the Miles operation are the production of an intestinal obstruction (obstruction colostomy) at the same time that a retroperitoneal infection is produced in a large, undrained, open surfaced cavity.

It is these undesirable factors that have led those dealing with cancer of the rectum to incline toward a one-stage combined abdominoperineal removal of the rectum when patients could pos-



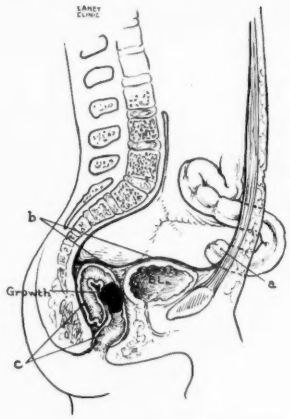


Fig. 8, left. Drawing showing the first stage of the Miles procedure in which the sigmoid is cut across and an end or transverse colostomy established, all of the blood supply to the rectum ligated, the rectum dissected from its pelvic attachments, the unnourished, fæcal contaminated rectum, *a*, pushed down into the pelvis and the pelvic parietal peritoneum, *b*, sutured over it.

Fig. 9. The second stage of the combined abdominoperineal operation completed after the preliminary loop colostomy as suggested by W. J. Mayo. Note the undesirable blind stump, *c*, made by one efferent limb of the loop colostomy when the sigmoid, *a*, is cut away from it. Exclusive of the preliminary loop colostomy, this illustration and plan is the same as the Miles procedure. The entire blood supply of the rectum has been ligated and the unvascularized bowel, *c*, has been dissected from its pelvic attachments, pushed into the dissected pelvis, and the pelvic parietal peritoneum, *b*, sutured over it.

sibly stand it. By this plan the colostomy is produced, but the immediate removal of the rectum through the perineum after the abdominal part of the operation is completed, not only does away with the implantation of the dead fæces-infected rectum in the closed pelvic pocket, but also permits the establishment of good posterior drainage. This one-stage plan of procedure is often not practicable, however, because the shock it produces is great and because many of the patients are too debilitated to endure such an extensive operation. In addition, the combination of extensive pelvic dissection, the intraperitoneal manipulation in making the colostomy together with the removal of the rectum, and, at the same time, the production of an intestinal obstruction by the obstructive colostomy still provide factors well calculated to cause a high mortality.

In the course of our study of patients between the first and second stages of the Miles procedure, another disadvantage presented itself in the disproportionate division of time necessary for the two stages, the abdominal part being time-consuming and shock-producing while the perineal part often took not over 10 or 15 minutes. Yet, the very nature of the operation makes necessary the division into abdominal and perineal stages.

That the Miles plan is not entirely satisfactory is evidenced by the variety of modifications which have been devised and described from time to time.

Appreciating the necessity of having the bowels moving well through an established colostomy and the necessity of avoiding the mortality-producing factor of an intestinal obstruction combined with a major intra-abdominal operation before the abdominal part of the abdominoperineal removal was undertaken, W. J. Mayo in 1912[1] proposed the preliminary establishment of a loop colostomy and the delaying of the abdominal portion of the abdominoperineal removal until all obstruction had been overcome and the bowels were moving well.

The disadvantages of this plan, shown in Figure 9, are, first, that when the sigmoid is cut away from the efferent loop of the loop colostomy at the second stage removal, a short efferent stub of colon remains attached to the abdominal wall. Surgeons who have done this operation have reported to us in personal communications that more than once the sutured end of this stump has opened, leaked, and caused a fatal peritonitis. That this is a real menace is shown by Rankin's admonition that when this type of operation is done, the blind

[1] Mayo, W. J. Am. Surg., 1912, lvi, 240.

stump of colon should be removed. This plan of procedure is similar to the Miles plan and except for the preliminary loop colostomy, has the disadvantages that the abdominal part of the removal of the rectum represents a disproportionate division of the abdominoperineal removal and thus the procedure still possesses the most undesirable factor of the abdominoperineal removal, namely: the blood supply to the lower segment of the rectum is ligated and a dead segment of bowel is pushed down into the recently dissected pelvis, which is converted into a tight pocket by the reconstruction of the pelvic peritoneum over it.

Another point hardly a drawback, however, is that the operation thus becomes a three-stage procedure. It overcomes but one undesirable factor, intestinal obstruction, and necessitates the removal of the blind efferent stub of the loop colostomy in a septic field—a procedure not without considerable disadvantage.

Various suggestions have been made to overcome the difficulties mentioned. Rankin[1] has suggested that the colon be cut directly across and that a transverse or end colostomy be established, the cut end of the lower segment of bowel being cut and dropped back into the abdomen as a sutured blind end of the lower segment of rectum and kept there until that segment is to be removed (Fig. 10). This procedure has not appealed to us, for it prevents the irrigation of the lower segment of bowel and the cleansing of it of its fæcal contents. This procedure is also impracticable if there is any degree of obstruction at the site of the growth in the lower segment of bowel below the sutured end.

Preliminary and permanent cæcostomy has been proposed and practiced by some surgeons as a means of overcoming the obstruction which is occasionally present in these cases and of establishing an abdominal outlet to the fæcal content. Cæcostomy as a permanent fæcal outlet is undesirable because of the liquid character of the fæces at this point, and because as a preliminary measure it does not permit of complete sidetracking of the fæcal stream and of the cleansing of the segment of bowel below its level. Because of the solid character of the fæces at this point and because it provides a fæcal reservoir for solid fæces, left sided or central colostomy, preferably in the sigmoid or low descending colon, remains as the best site for a permanent colostomy.

Dahlgren,[2] in 1913, proposed and practiced a plan of preserving the blood supply to the rectum by the following method: The abdomen was opened and the vessels to the lower sigmoid and rectum were ligated central to the marginal vascular arch for a distance corresponding to about 25 centimeters of bowel, the blood supply to the lower segment of bowel being maintained through the marginal vascular arch and its anastomosis with the left colic artery (Fig. 11). The cæcum was attached to the abdominal wall in the right iliac fossa (Fig. 12, inserts A and B), the sigmoid with its centrally ligated vessels was dropped back into the abdomen, and the abdominal wall was closed. On the following day, because of necessity, the cæcum was opened and the cæcostomy was established. Some days later the rectum was dissected free through the perineum and pulled down until the segment of bowel appeared opposite which central ligation of its mesentery had been done, the marginal vessel in the vascular arch was ligated, the bowel cut between clamps, above the growth, and the end sutured; the pelvic peritoneum was sutured to the rectum, the end of which had been closed by sutures, thus making a blind extraperitoneal stump (Fig. 12).

There is little in Dahlgren's procedure to recommend itself except the method of maintaining the nourishment of the rectum by central ligation of its vessels, the preservation of its marginal vascular arch, and the anastomosis to the left colic artery.

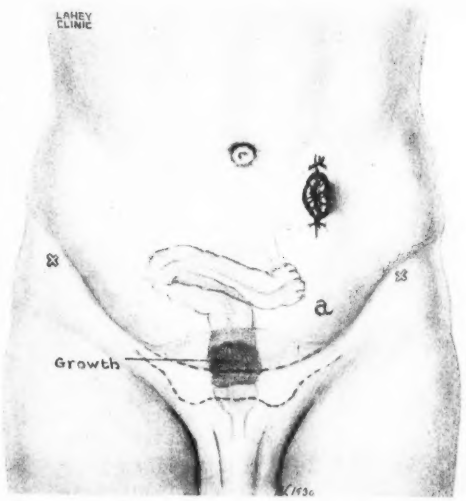


Fig. 10. Dr. F. W. Rankin suggests that a transverse or end colostomy be established and the distal end, *a*, of sigmoid sutured over and over and dropped back into the abdomen, to remain as a blind end until the second-stage removal.

[1] Rankin, F. W. Surg., Gynec. & Obst., 1929, xlix, 193.
[2] Dahlgren, Karl. Zentralbl. f. Chir., 1913, xl, 13, 457.

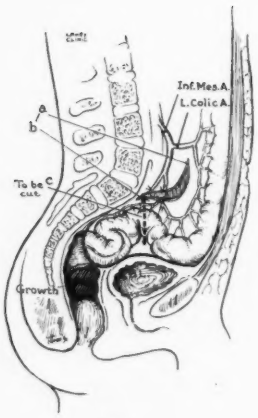


Fig. 11.

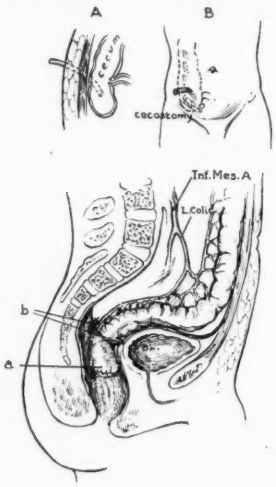


Fig. 12.

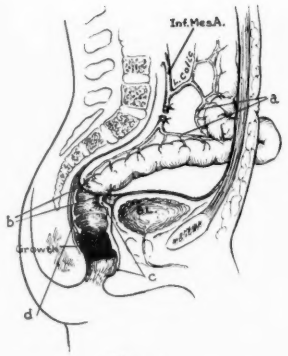


Fig. 13.

Fig. 11. The central incision, as suggested by Dahlgren, in the mesentery of the sigmoid with ligation of the sigmoidal and superior hæmorrhoidal vessels, the nourishment to the lower rectum being maintained by preservation of the marginal vascular arch. The shaded area, *a-b*, represents the incised mesenteric root. The dotted line, *c*, represents the level above the rectal growth at which the rectum is to be cut across and pulled down when the lower rectum and growth are removed at the next stage through the perineum.

Fig. 12. The lower rectum and growth have been removed through the perineum. The bowel has been cut across and sutured after the perineal removal so that the point *a* corresponds to the point on the rectum in Figure 11 marked by the dotted line *c*. The pelvic parietal peritoneum, *b*, has been sutured to the sigmoid to make its blind end extraperitoneal. The inserts A and B showing the cæcostomy are included to make clear that fæcal drainage was obtained at this point. This procedure ha little to commend it but is of value in that it suggests th retention of viability in the lower segment of rectum b preservation of the marginal vascular arch.

Fig. 13. The first stage of the plan suggested by D. F Jones, the central ligation of the sigmoid and rectal blood supply with preservation of the marginal vascular arch and the establishment of a loop colostomy. This differs from all others in that the rectum is dissected from all of its pelvic attachments at this first stage down to the levators but its blood supply is still maintained through the marginal vascular arch, *a*, and its communication with the left colic artery, and the pelvic parietal peritoneum is sutured to the vascularized pelvic colon well above the level of the growth, *b*, so that when the second stage perineal removal is made it will be entirely extraperitoneal, *c*, and the bowel above the growth can be cut across and sutured extraperitoneally at the point, *d*.

In 1915, D. F. Jones[1], of Boston, proposed an operative procedure by which the nourishment of the lower segment of sigmoid and rectum was maintained by central ligation of the vessels in the mesentery of the sigmoid with preservation of the marginal vascular arch—a plan similar to Dahlgren's. Jones' operative plan, however, was different. It consisted in the freeing of the rectum from the hollow of the sacrum, the bladder, or uterus, and from its lateral attachments intra-abdominally, the production of a loop colostomy, and the intra-abdominal attachment of the loosened pelvic parietal peritoneum to the dissected rectum wall above the level of the growth, and above the level of the point across which the rectum was to be later cut across. Below this point the entire rectum was removed in the second stage (Fig. 13). Thus, after the perineal removal of the rectum and growth, a loop colostomy was left above with a blind efferent end similar to that when the W. J. Mayo plan is used except that the end of the blind loop was long and extraperitoneal in the pelvis. This scheme permitted the establishment of the colostomy and the fæcal stream. It permitted irrigation and cleansing of the lower segment of bowel and permitted as much delay as desired between the abdominal and perineal steps of the operation. It further permitted the posterior and perineal steps of the operation to be done extraperitoneally, since the peritoneum of the pelvic floor had been sutured to the tube of rectum above at the anticipated level of transection, thus shutting it off from the peritoneal cavity.

This operation worked very satisfactorily in Dr. Jones' hands and is an excellent procedure. If it has drawbacks, they seem to us to be that a blind distal spur of sigmoid must be left, that the suture

[1]Jones, D. F. J. Am. M. Ass., 1915, lxv, 9.

of the lower end of the sigmoid when cut between clamps in the narrow pelvis during the posterior removal must be difficult and sometimes uncertain. There must be some limitation of the amount of sigmoid which can be removed together with its mesentery, since enough mesentery must be preserved to reach below the level of the pelvic peritoneum as far as the distal spur of the loop colostomy.

Two other plans of procedure in the abdominoperineal removal of cancer of the rectum have been proposed by Dr. R. B. Coffey, of Portland. One is the complete ligation of all of the blood supply of the section of the rectum, the introduction of a rectal tube, suture of the ligated distal end of the bowel to this tube, withdrawal of the tube, and telescoping of the rectum on itself until pulled through and out of the anus, where it is held by pins. Since this plan is not applicable to growths which in any way constrict the rectum, it needs but mention as one of the possible plans of procedure.

Dr. Coffey's other plan is similar to that of Miles except that by suture of the lax peritoneum above the pubes in the male, an extraperitoneal tube is constructed about a drainage wick which leads down to the dead segment of bowel within the pelvis and below the sutured diaphragm of pelvic peritoneum. The disadvantages of this plan are that a dead segment of fæces-infected bowel is placed in a raw and completely dissected pelvis at the same time that, as in the other methods, an extensive intra-abdominal operation is done. It has the advantage, however, that drainage is established down to the infected and dead segment, thus overcoming the urgency of removing that segment within a limited number of days.

SUMMARY AND CONCLUSIONS

We have employed the operative plan described upon 7 patients with cancer of the rectum. This method is itself not without undesirable features but, as a two-stage operation, has so far appeared to offer a nearer approach to the ideal one-stage abdominosacral removal of cancer of the rectum than have other procedures.

As much delay and preparation as desired are possible between the first and second stages of the operation.

The duration of the steps is better divided, the greater part being done in the second stage when the patient is in the best state of preparation.

The necessity of implanting dead bowel in the pelvis is overcome.

The second stage involves the removal of a clean, empty rectum.

Good posterior drainage is established immediately after the extensive pelvic dissection.

FROM THE CLINICS OF TOURO INFIRMARY AND CHARITY HOSPITAL

THE SURGERY OF DIABETES AS IT CONCERNS GANGRENE OF THE LOWER EXTREMITIES AND CARBUNCLES

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THE surgery of diabetes, it has been repeatedly pointed out, has been transformed since the introduction of insulin. Formerly, at least for certain procedures, the mortality reached 50 per cent, and operation was seldom undertaken except under the impetus of stark necessity. Now large series of cases are being reported in which the mortality, for unselected operations, ranges from 2 to 10 per cent, and deliberate, elective surgery is being done with routinely good results. We have come to agree with Lord Moynihan that it is not the part of wisdom to permit a patient to die of a disease which can be remedied by surgical measures—or to live with it, for that matter—merely because he happens to have something else the matter with him.

It is a regrettable fact that the number of diabetics seems to be steadily increasing, which means, in turn, that the amount of surgery necessary on them is steadily increasing. This group of patients is liable to every surgical disease to which the rest of mankind is liable, and it is particularly susceptible to two special surgical diseases: gangrene, chiefly of the lower extremities, and infection, chiefly in the form of carbuncles of the neck. The diabetic patient, therefore, presents two conditions, a local surgical lesion as well as an associated constitutional disease, which latter, if duly considered, is usually of relatively small moment, but which, if ignored, almost always means swift and certain death. Unprepared, he is a poor risk for any sort of surgery; properly prepared, other things being equal, he is almost as safe a risk as his non-diabetic brother.

The importance of the preparation of the diabetic patient cannot be too strongly stressed. His safety is not a matter of chance. It rests upon unceasing vigilance, upon unceasing attention to detail, upon a pre-operative care almost mathematical in its exactness, upon a post-operative care equally scientific. Most of all it rests upon the close co-operation of internist and surgeon, for diabetes, in its surgical phases, demands a dual control.

That the rationale of these precautions may be clear, it might be well just here to point out the clinical pathology of diabetes. It is essentially a metabolic disease, caused by a deficiency in the internal secretion of the pancreas, manifested by the presence of sugar in the urine and an excess of sugar in the blood, and characterized, at least in its graver stages, by a tendency to acidosis and coma. If these things are so when the diabetic is in what we may term his normal state of health it follows that his disabilities must be even more pronounced under abnormal conditions, when his bodily functions are disturbed, when his metabolism is more depraved than it is ordinarily, when his diet is unbalanced by the phenomena which accompany his illness, when his already existing handicap is increased and aggravated by the existence of another disease more or less serious in itself.

It follows, therefore, that the surgery of diabetes, no matter how urgent it may be, cannot be lightly undertaken. On the other hand, it must be done without delay, for diabetics tolerate infection badly and infection increases their diabetes; they are in the grasp of a vicious circle which must be interrupted promptly if they are not to succumb to the double burden which they are being called upon to bear, and which insulin, their safeguard at other times, is powerless to lighten. For it is unhappily true that in the presence of acute infections, at a time when its aid is most needed, insulin loses from 50 to 75 per cent of its efficacy, and the dosage must be materially increased to control the constitutional disease. Both the surgical and the diabetic phase of the illness demand prompt and earnest consideration. As Joslin puts it, the patient who is treated first for diabetes and second for his surgical condition is likely to have a very brief illness, but it should likewise be pointed out that the patient who is treated for his surgical disease and whose diabetes is disregarded is likely to have an equally short career. Which brings us to our original thesis, that only by the close co-operation of internist and surgeon can the patient's best interests be served.

As a matter of fact, it is chiefly to the medical man that the safety of diabetic surgery is due. Except that promptness of action and absence of

Fig. 1, above. Schematic drawing of lines of skin and bone section in the preferred amputation for diabetic gangrene of the lower extremities.

Fig. 2. Right angle muscle section at level of retracted skin.

Fig. 3, left. Appearance of limb after skin and muscle section, and method of sawing bone.

Fig. 4. Closure of the stump by means of figure-of-eight sutures.

trauma are more imperative than usual, surgical principles remain surgical principles. Joslin and Foster, Wilder and Duncan, John and Lemann, and others of like knowledge and ability are the men to whom the surgeons owe whatever success they have achieved in this particular field. Practically all of my own cases have been prepared for operation under the direction of Dr. I. I. Lemann, and he has kindly written for me the following résumé of his treatment:

"Diabetic patients without infection who are to undergo elective surgery should be brought into the best possible condition by adjustment of their diet and the administration of insulin if necessary. Operation should be deferred until the urine is free of sugar and ketone bodies, and until the blood sugar is within or near normal limits, though this latter requirement cannot always be strictly met. For at least 2 days before operation the diet should be fairly liberal in carbohydrates, even though insulin must be given to offset them, in order to permit the necessary storage of glycogen in the liver. Some hours before operation, usually at midnight, an extra feeding of carbohydrates, such as oatmeal or orange juice, is given, and an additional dose of insulin is given if necessary.

"On the operating table 20 cubic centimeters of 50 per cent glucose solution is given intravenously, with insulin by hypodermic to insure its utilization, the amount of the latter depending upon the severity of the diabetes. In mild cases, where previous to the administration of glucose there has been no glycosuria, at least 1 unit of insulin is given for every dram of glucose. The point of this therapy is to offset the postoperative period of starvation and possible vomiting, though this latter complication is usually absent in patients treated by this method and operated upon under ethylene anæsthesia.

"After operation the surgeon is requested to proceed as if the patient were not a diabetic. Sweet drinks are given, or glucose by proctoclysis, this diet being offset by the administration of insulin every 4 hours in doses regulated by the intensity of the Benedict reaction in the urine.

"The second group of patients comprises those who have infections either essentially dependent upon the diabetes, such as gangrene, or occurring merely as a complication, such as acute appendicitis, and in whom prompt operation is imperative. All possible safeguards are employed, though no time must be lost in preliminary preparation. Operation is done preferably under local or spinal analgesia, though ethylene may be used where these are impractical. Glucose and insulin are administered on the operating table, as has been described, and after operation fluids are forced and the diet is rich in easily available carbohydrate food. Insulin is used at regular

intervals. In short, such patients, before and after operation, are treated as if coma were impending."

In all surgical procedures on diabetics, anæsthesia is an important consideration. Ether, generally speaking, is contra-indicated. Even in healthy, non-diabetic patients it produces a tendency to acidosis and hyperglycæmia, dangers which must be doubly guarded against in diabetics, in whom these disabilities already exist. It is true that at the Mayo Clinic ether is used freely, but it must not be forgotten that the percentage employed there, because of the surpassing skill of the staff of anæsthetists, is well below the margin of safety, and that such results cannot be expected generally.

Local analgesia should not be employed unless there are definite contra-indications to every other type. Even in healthy persons the percentage of infections with it is two or three times what it is with general anæsthesia,[1] and this percentage is markedly increased in diabetics, whose tissues are notoriously non-resistant to the insults of trauma and who develop infection on very slight provocation. Ethylene anæsthesia is most generally satisfactory, as well as safe, and in the cases in which it is contra-indicated we have found spinal analgesia by the method of Pitkin equally good, particularly in operations below the umbilicus and on the lower extremities.

To consider specific conditions, the gangrene of diabetes is usually superimposed upon an already existing arteriosclerosis, which, because of hyperglycæmia, develops at an earlier age (10 years earlier, according to Eliason), than the usual arteriosclerosis. It may follow infection or be followed by it, and in the former case it is most often precipitated by improper hygiene of the feet, the wearing of ill-fitting shoes and hose, the use of radical corn cures, and the cutting of corns and calluses. So frequent, as a matter of fact, is this chain of events that internists realize the importance of warning their diabetic patients of the dangers of these apparently trivial things, though all too often their warnings go unheeded.

Once gangrene has developed, the first link of co-operation between the internist and the surgeon must be forged. The surgeon must be called into consultation promptly. He must be given an opportunity to practice his art upon a living, not a moribund patient, to exercise conservatism while conservatism is still a possibility. Emergency amputations upon desperately ill patients are mute evidence that somewhere along the line there has been a lack of co-operation.

[1]This point was proved statistically by the author from a study of 457 hernia operations from the records of Touro Infirmary. Maes, Urban. The proper evaluation of local anesthesia. New Orleans M. & S. J., 1924, lxxvi, 492–495.

Thanks to insulin, diabetic gangrene does not necessarily, in these days, mean immediate amputation, for it is a dry gangrene, which, if the diabetes can be controlled, is sometimes amenable to conservative measures and is sometimes self-limiting. That, of course, is a consummation devoutly to be wished, for the patient who lacks a toe is in far better case than the patient who lacks a leg. On the other hand, it must be emphasized that these cases must be selected with meticulous care, that they must be watched unceasingly, and that there must be prompt resort to operation if there is not absolute evidence that the line of demarcation is definitely forming. Diabetic coma is an all too frequent accompaniment of diabetic gangrene, even of the apparently superficial variety, and the conservative surgeon, usually worthy of all praise, adds an appreciable percentage to the mortality of diabetic surgery. Finally, the patient's economic status cannot be ignored. The well-to-do patient can afford a long period of disability, the moderately-circumstanced or frankly poor patient, with others dependent upon his efforts, cannot so indulge himself, and prompt amputation may serve his interests better than the conservatism which might be desirable otherwise.

Amputation has always been a surgical problem for the reason that it does not always seem possible to reconcile safety, primary healing, and future usefulness. The major premise of the old surgical law of Heidenheim is that amputation should be done above the knee routinely, the reason being that primary healing is more likely to occur in that location because the collateral circulation is more satisfactory there. Against this routine, however, are two arguments: that in all amputations the mortality rises in direct relation to the nearness of the point of amputation to the trunk, and that it is seldom possible to fit an artificial limb satisfactorily above the knee. A pressure-bearing stump can be obtained with little difficulty, but leverage to manipulate the leg is lacking. This is a point which cannot be overlooked, for there is more to surgery than merely saving life. Usefulness afterward, particularly in patients in moderate or impoverished circumstances, is almost as important a consideration, particularly in these days when the span of life of diabetics can be prolonged indefinitely by the use of insulin.

For many years past we have in my own clinic steadfastly considered this aspect of the case, and we have arrived at the conclusion that the chief reason for failure of primary healing in amputations below the knee is not a defective blood sup

ly but a too elaborate technique. We are convinced that beveling, flap formation, and complicated dissection are merely invitations to local gangrene, to infection, and to upward extension of these processes, particularly in diabetics, in whom secondary amputation carries a mortality even higher than the high mortality ordinarily accompanying such a procedure.

It is our custom, therefore, to amputate at the point of election (the junction of the middle and upper third of the leg) by the old amputation of Kocher, the *en saucisson* method of the French writers, which was widely used and adequately tested in the emergency surgery of the War. We believe that this method is logical because the blood vessels of the extremities, in going from tissue plane to tissue plane, do so more or less at right angles, therefore the lines of section are made at right angles to the long axis of the limb, and therefore no tissue is left without its blood supply, there being at least a maximum circulation to the end of the stump.

The procedure is quite simple technically. The skin is incised, then allowed to retract; the muscles are sectioned at the level of the retracted skin, then allowed to retract; finally, the bone is sectioned at the level of the retracted muscles. To express it differently, each time the sectioning is done at a higher level, and the final effect is that of an inverted cone. After careful ligature of the blood vessels—no tourniquet is used, and the ligation is done individually, never *en masse*—the stump is sutured over in two planes, with a minimum amount of tension. Usually only three or four sutures are necessary to bring the tissues over the face of the stump, these being placed in the deep aponeurosis, and the same number are used to guide the skin together. Careful approximation is a minor matter. A figure-of-eight suture may be used with equal advantage, the deep portion of the suture holding the aponeurotic planes together, while the superficial ties guide the skin together. We are extremely careful of our hæmostasis, and as a result we do not consider drainage necessary; we believe, too, that while it leads nothing out, it may lead infection in.

The simplicity and swiftness of this procedure are paralleled by its excellent results. I have used it in approximately 60 cases, and the 3 deaths which have followed it all occurred in the pre-insulin days, when surgery was deferred too long and the diabetes was inadequately handled by the starvation method. In all but 2 of the other cases primary union has been the rule. In one of the exceptions drainage was done, many years ago, and infection resulted; the second patient had a marked infection superimposed on his gangrene, and refused operation for a week after it had been recommended. In both instances re-amputation had to be done above the knee. All of the other patients, however, could be fitted satisfactorily with artificial limbs, and were returned to their homes as potentially useful citizens.

Fig. 5. Gridiron incision employed in the treatment of carbuncles of the neck. Note that the lines of incision extend into the healthy tissues, well beyond the area of inflammatory reaction.

It might be well to add that the indications for amputation and similar details have purposely not been dwelt upon. They are fully and excellently described in the recent text on diabetic surgery written by McKittrick and Root, which is recommended without reservation to those interested in this special subject.

The general surgical principles which have already been stressed are transferred in kind to the management of carbuncles, to which diabetics are peculiarly liable. As in amputation for gangrene, the earlier the treatment is instituted, the better for the patient and the quicker his response to insulin. In my own clinic we have long since abandoned the usual methods of crucial incision and radical excision, because of the long period of disability which follows their use, as well as the great sacrifice of tissue inevitable with them. We have substituted for them the gridiron incision, which is entirely satisfactory in lessening the tension and providing an outlet for the infection, while at the same time healing is more rapid and the hospital stay is markedly decreased. The details of technique need no special description. After the incision there may be rather free hæmorrhage, but it is easily controlled by gauze

soaked in 1 per cent carbolic acid solution. No drainage is employed and no packs are used, so subsequent dressings are as painless as possible under the circumstances. In most instances, though the central parts of the central strips are likely to slough, the remaining strips of skin fall into place and act as grafts, and healing is surprisingly rapid.

It is scarcely necessary to point out that strong antiseptic solutions have no place in the skin preparation of diabetics. We have found benzine and iodine followed by iodine entirely satisfactory. We grant the virtues of the acriflavine preparation advocated by Tinker, but the cost is prohibitive for most institutions.

In the surgery of diabetes the principles of absence of trauma, of careful asepsis, and of as great swiftness as is consistent with safety are even more vital than they are in ordinary surgery. We are dealing with patients whose resistance is lowered by a constitutional disease, whose constitutional disease may be aggravated, in spite of the safeguards thrown around it, by the surgical insults which are inevitable in the correction of a surgical disease, whose tissues are notoriously susceptible to infection, and who frequently exhibit, in addition to diabetes, other degenerative diseases incident to middle life and advancing age. Insulin is an ally but it is not a universal protection against every complication, and its employment should not arouse a false sense of security. The surgery of diabetes is no longer an occasion for timidity and fear, but likewise it is not an invitation to unwisdom, and the success of any surgeon, in this disease as in others, will be in exact proportion to the judgment he displays and to the skill, the gentleness and the swiftness with which he does his work.

SUMMARY

1. Since the introduction of insulin diabetic patients have become relatively safe surgical risks, provided the pre-operative preparation and postoperative care be adequate.

2. An outline is given of the principles of the medical care of surgical diabetics, as practiced in the clinic of Dr. I. I. Lemann.

3. The circular amputation of Kocher is recommended for diabetic gangrene of the lower extremities, and the gridiron incision is recommended for the treatment of carbuncles of the neck.

4. The general surgical principles of absence of trauma, of careful asepsis, and of swiftness consistent with safety, are more vital in the surgery of diabetes than in ordinary surgery.

A METHOD OF RECONSTRUCTION OF AXILLA FOR CONTRACTURE

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IN the following article is described a method for reconstruction of the axilla, done in stages and consisting essentially of the transplantation of skin flaps from a distance with maintenance of their blood supply through tubed flaps which are in turn utilized in the reconstructive procedure.

Burns involving the axillary folds will often, in the process of healing, produce cicatrices which extend into the subcutaneous tissues and often into the pectoral muscles, binding the arm to the side and preventing abduction at the shoulder. This serious disability may often be avoided if the surgeon adopts preventive measures during the period of healing. These include maintenance of the arm in full abduction following the receipt of the burn or injury, and the application of Thiersch grafts to granulating areas as soon as the appearance and bacteriology of the wounds permit. The more general adoption of the latter principle, stressed by Lyle, will undoubtedly decrease the incidence of contractures following burns of this and other parts of the body.

Unfortunately, patients frequently present themselves with contractures already present, and the problem of replacing the binding scars by normal tissues and restoring form and function confronts the surgeon. To correct contractures of the axilla, many methods have been described and carried out with varying degrees of success. Probably the simplest of these consists in the division of the contracting scars, forcible abduction of the arm, and the immediate application of Thiersch grafts to the resulting wound. Experience seems to show that this method has little to commend it. The rapid recurrence of the contracture following this procedure may be attributed to the fact that the method does not include excision of the scar tissue, a primary principle in the successful treatment of all contractures.

The most commonly employed treatment makes use of the principle of the shifting of adjoining normal tissues after extensive undermining and following excision of the scar. This may be done in one or more stages. During the period of healing, the arm is maintained in abduction. Many successful results have been reported. This method is hardly applicable where the burns have been extensive and have involved large areas of skin. Its use would not be feasible when there is bilateral axillary contraction. A serious objection to the method is the fact that the skin flaps are usually repaired under con-

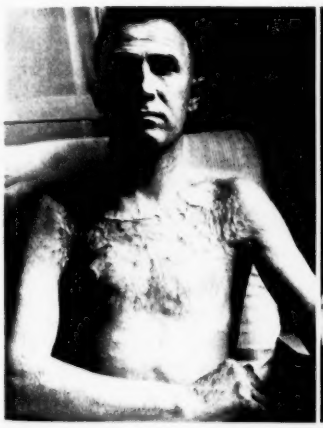


Fig. 1.

Fig. 2.

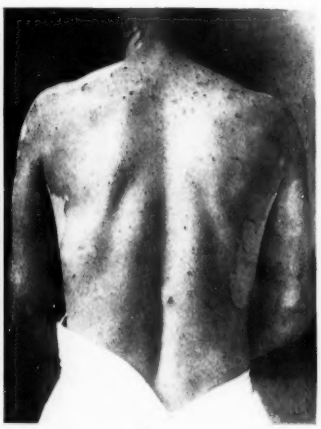


Fig. 3.

Figs. 1 and 2. Appearance of patient following the application of Thiersch grafts. Figure 2 indicates the extensive scarring in the axillary folds and the limit of abduction at this time. Figure 3 is a posterior view of the patient and shows the extent of the burns.

Fig. 4.

Fig. 5.

Fig. 6.

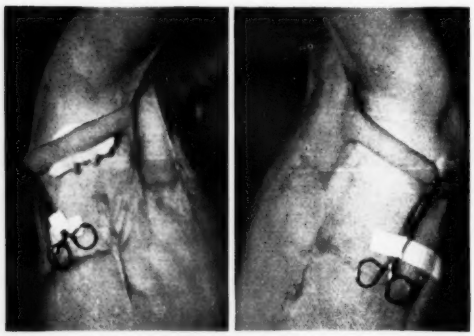
Fig. 4. Condition following the first operation. Photograph indicates the position, direction, and length of the tubular flaps fashioned on the posterior aspect of the thorax.

Figs. 5 and 6. Appearance of wounds following the second operation. It will be noted that a rectangular flap of skin measuring 2.5 by 6 inches, has been lifted away from the underlying fascia on three sides, thus insuring adequate blood supply. This flap remains attached to the chest wall on its fourth side and by the tubed flap. The size of each flap corresponded to the expected deficiency in the axilla following excision of the scar.

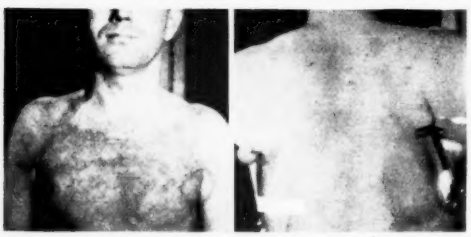
siderable tension. Should necrosis take place, the surgeon would be confronted with a more serious problem than the original one.

Within recent years, the use of the free full thickness graft has become more extended. Its field of applicability is gradually being widened. It may be used with success in the treatment of contractures involving other parts of the body, notably, the popliteal regions, the hand, and the fingers. The writer has had no experience with this type of treatment for contractures of the axilla. A number of theoretical objections to its use here arise. The most important of these is the fact that the resulting wound in the axilla following excision of the scar is of such uneven contour as to lend itself very poorly to the application of firm even pressure which is of paramount importance following this type of skin graft. Then again, it may be stressed that the use of this form of graft is not uniformly successful.

Recently, the writer was confronted with the problem of reconstructing both axillæ of a patient



Figs. 7 and 8. Condition of patient following the third operation, 2 weeks later. Each rectangular flap has been completely dissected on four sides, and swung around by means of the pedicled flap to fit into the deficiency in the axillary region created by the total excision of the scar. The photographs also indicate the method used for compression of the tubed flaps by means of rubber bands.



Figs. 9 and 10. The anterior view of patient shows the skin insertions in the axillary folds following the third stage. The posterior view shows the posterior extremities of the original tubed flaps with the method used for elastic compression of the pedicles.

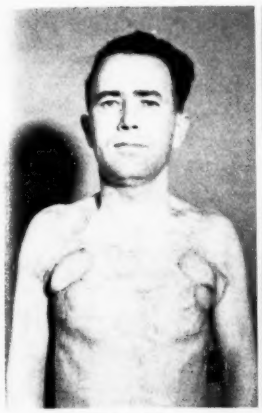


Fig. 11.

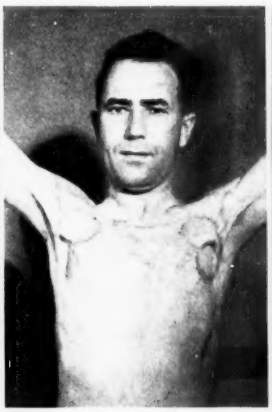


Fig. 12.

Figs. 11 and 12. Appearance of patient following the fourth stage done 2 months later. The pedicles of the original tubular flaps have been divided. Each flap has been turned upon itself after being converted into a flat flap, and inserted into defects in the anterior axillary regions created by further excision of scar tissue. Figure 12 indicates the limit of abduction following this stage.

Fig. 13.

Fig. 14.

Figs. 13 and 14. Lateral views of axillæ after fourth operation, showing scars on posterior aspect of chest wall, and position at this time of original tubular flap.

who had received severe burns involving the entire anterior chest wall. The scarred area was so extensive as to preclude the use of any of the recognized skin shifting operations. The plan finally evolved and carried out, took cognizance of the following principles:

1. Complete excision of all scar tissue which prevented full abduction of the shoulder. This included excision of cicatricial bands extending into the pectoral muscles.

2. The transplantation of skin flaps from a distance, with maintenance of their blood supply through tubular flaps.

3. The necessity of avoiding vertical suture lines.

4. The replacement of the binding scars by normal pliable skin and subcutaneous tissues.

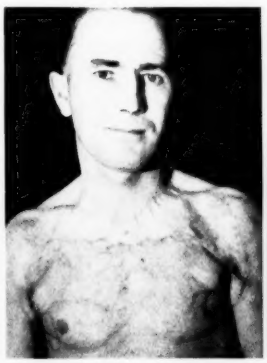


Fig. 15.

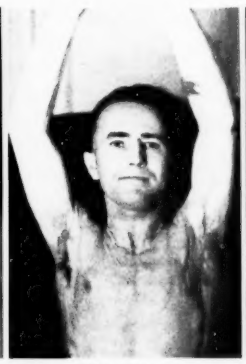


Fig. 16.

Figs. 15 and 16. Appearance of patient following the fifth and final operation done 3 weeks later. The remains of the original tubular flap have been freed from its distal two-thirds, and untwisted. A strand of scar tissue running vertically in the axilla (Fig. 12) was excised and the remainder of the tubed flap was inserted into this defect so as to run transversely from before backward in the center of the axilla. Figure 15 indicates the normal contour of the axillary folds. Figure 16 indicates the return of full abduction at the shoulders. It will be noted that the transplanted skin in its final position has the shape of a cross, the long arm of which is the original rectangular flap and the cross-piece of which corresponds to the original tubular flap, divided into two segments.

Fig. 17.

Fig. 18.

Figs. 17 and 18. Lateral views of the chest wall showing the scars which mark the sites of the original skin flaps.

Fig. 19.

Fig. 20.

Fig. 21.

Fig. 19. Posterior view of patient after final operation.
Fig. 20. Photograph of patient presenting contracture of one axilla following extensive burns.
Fig. 21. Photograph of same patient indicating the extent of abduction.

The history of this case is reported herewith in detail, and the various stages are indicated in the accompanying photographs:

H. C., aged 29 years. The patient received severe burns involving the front of the chest and both upper extremities, on June 17, 1928, in a gasoline explosion. He was removed to a hospital in Long Island where his condition was critical for a few days. He was treated at this institution with various dressings until the date of his admission to the New York Hospital, August 18, 1928.

Examination at this time showed an extensive granulating wound over the front of the chest, extending from the supraclavicular regions to the level of the ensiform cartilage, and from one axilla to the other. The skin of both hands and forearms was thin and parchment-like. There was considerable impairment of function in all the finger joints, while abduction at the shoulders was impaired 95 per cent. The granulating wound on the chest was treated by the Carrel-Dakin method until bacteriological examination revealed sterile cultures. The entire wound was then covered with Thiersch grafts taken from the thighs. Two weeks later, the patient was discharged from the hospital with all wounds healed. Figures 1, 2, and 3, indicate the appearance of the scars at this time, and the extent of abduction at the shoulders. It will be seen that the contracting scars involved mainly the anterior axillary folds.

He returned in October, 1928, at which time examination showed that all the wounds were healed and that there was marked improvement in motion in the finger, wrist, and elbow joints. However, there had been no improvement in shoulder abduction. Because of the bilateral involvement and the extensive scarring in the neighboring tissues, a skin shifting operation seemed out of the question. Therefore, the following procedure was carried out in stages:

On October 29, 1928, two tubular skin flaps were fashioned on either side of the chest posteriorly near the axillæ (Fig. 4). The skin flaps used to form these tubes measured 2 inches transversely and 7 inches longitudinally, and were directed downward and outward. Eleven days later, the second stage was performed. On each side of the chest wall and continuous with the distal extremity of each tubed flap, a rectangular flap of skin and subcutaneous tissues, measuring 2.5 by 6 inches, was marked out. It was completely dissected away from the underlying fascia on three sides (Figs. 5 and 6). The furthermost skin attachment was left intact to insure an adequate blood supply. An unfortunate experience with another case emphasized the fact that, if this flap is separated on all four sides, necrosis of its distal extremity is prone to occur. The size of this flap corresponded to the expected deficiency in the axilla after excision of the scar tissue. The flap was then replaced in its original bed following careful hæmostasis, and the skin edges were sutured with interrupted fine silk worm gut. The purpose of this procedure was to permit of the formation of new blood vessels through the tubed flaps before complete severance from the chest wall.

Two weeks later, the third stage was performed. The rectangular flap of skin, which had been lifted at the second operation, was separated

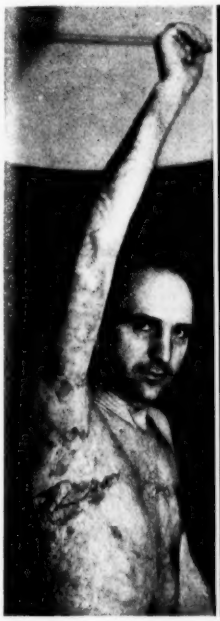


Fig. 22.

Fig. 23.

Fig. 24.

Fig. 22. Final result following the use of the operative procedure which has been fully described in the text. Photograph indicates complete abduction at the shoulder joint.

Fig. 23. Anterior view of same patient showing normal axillary fold contour.

Fig. 24. Posterior view of same patient showing the scars on the chest wall marking site of original flaps.

completely from its bed on all four sides, its only attachment to the body being through the original tubular flap. The remaining wound on the chest wall was then repaired by a plastic undermining and shifting of the skin edges. The scar tissue in the anterior axillary folds was then excised. Numerous strands of cicatrix extending into the pectoral muscles were removed. The arm was then widely abducted. This left a defect in the axilla of the same size as the rectangular flap above described. The tubed flap was then swung around below the axilla, and the rectangular skin flap accurately fitted into the defect in the axilla. Fine silk worm sutures were used to approximate the skin edges. Great care was given to hæmostasis and the obliteration of dead spaces. The latter was aided by placing fine catgut stitches uniting the subcutaneous tissues of the flap to the wound in the axilla. A similar operation was performed on the opposite side. Pads were applied in both axillæ so as to exert firm, even pressure on the skin flaps. At the same time, great care was exercised to prevent any pressure on the tubular flaps. Convalescence following this extensive operation was uneventful, and the wounds healed by primary union (Figs. 7, 8, 9, and 10.)

Six weeks later, elastic compression of the pedicles of the tubular flaps was instituted. This was done gradually and extended over a period of 2 weeks, the period of compression by rubber bands being increased daily. Just prior to the fourth operation, rubber band compression was maintained for a period of 24 hours (Figs. 7, 8, and 10). This operation was done on February 14, 1929, 2 months after the third stage, and consisted of the following: The posterior ends of the pedicled flaps were divided transversely, and the remaining wounds on the chest wall marking the pedicles were repaired by a plastic undermining of the skin edges. Each tubed flap was then opened along its original suture line over a distance amounting to three-quarters of its length. This procedure converted the tube into a flat piece of skin and subcutaneous tissue, measuring 2 inches transversely and 5 inches longitudinally. Each flap was then turned upon itself and drawn forward across the front of the

anterior axillary fold. An area of scar measuring 1.5 by 3 inches was excised from the anterior axillary fold. Scar tissue extending into the pectoralis major muscle was excised. The flattened tubed flap was then laid into this deficiency and sutured into place with fine silkworm gut. Dead spaces were obliterated. Pressure bandages were applied and the arms were put up in abduction. These wounds healed by first intention (Figs. 11, 12, 13, and 14).

The fifth and final operation was performed 3 weeks later. The pedicles of the skin inserts made at the fourth operation, were divided transversely, thus freeing the remaining third of the original tubular flap. The edge of each scar insert was then sutured to the remainder of the wound in the anterior axillary region after excision of some underlying scar tissue. The remainder of the original tubed flaps was then untwisted and opened along its suture line, thus being converted into flat pieces of skin. A ridge of scar tissue in the center of the axilla marking the suture line of the original skin flap (Fig. 12) was excised leaving a deficiency on the right side extending backward and outward, and on the left side extending backward. These deficiencies corresponded exactly in size to the opened up remains of the tubed flaps. The latter were then sutured into these defects with fine silkworm gut. The wounds healed by primary union.

Following the last operation, the patient rapidly recovered full function at the shoulders. The final result is indicated in Figures 15, 16, 17, 18, and 19. They portray the complete restoration of function, restoration of normal contour of the axillæ, and a minimum amount of scarring.

A second patient presenting a unilateral involvement, but with extensive scar tissue involving the anterior chest wall, was treated by the same method (Figs. 20 and 21). The end result is indicated in Figures 22, 23, and 24.

SUMMARY AND CONCLUSIONS

A method for the correction of contractures of the axillæ is presented. It recognizes the following principles:

1. Excision of all scar tissue.
2. Transplantation of skin flaps from a distance with maintenance of their blood supply through tubular flaps.
3. The necessity of avoiding vertical suture lines.
4. The replacement of the binding scars by normal skin and subcutaneous tissues.
5. The restoration of the contour of the axillary folds.

RESECTION OF THE RENAL PELVIS FOR HYDRONEPHROSIS: ITS COMPLICATIONS AND RESULTS[1]

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PIONEER work in the plastic operations on the renal pelvis for hydronephrosis was done by Trendelenburg, Kuster, and Fenger. Kuster, in 1891, reported a method of securing drainage of a hydronephrotic renal pelvis by severing the ureter from its abnormal pelvic attachment and anastomosing it to the dependent portion of the pelvis. He used the method in one case. Fenger, in 1892, stated that he had performed the first successful plastic operation for the formation of valves which produced hydronephrosis. The patient was aged 28 years and had had symptoms of hydronephrosis for 8 years. Bazy, in 1896, using Kuster's method, performed the first successful operation of this type in France. This was followed by reports of successful operations by Albarran, Tuffier, and Delbet. Quinby, in 1922, reported 3 cases of hydronephrosis in which he had performed plastic operations, and in 1927, he reported 7 cases in which the ureter had been successfully transplanted to the dependent portion of the renal pelvis. At that time hope was expressed that postoperative tests of renal function and postoperative pyelograms of kidneys that had been operated on, would be made in other cases, to eliminate the possibility of silent renal atrophy. This was done in a series of cases reported by Walters and Braasch. In this paper I shall describe the technique used in these cases and in other successful cases of resection of hydronephrotic renal pelves and report on certain postoperative complications which have necessitated secondary nephrectomy.

A short review of the causes of ureteropelvic obstruction that produce hydronephrosis may explain the reason for a choice of operative procedures. In my experience, the causes consist for the most part of anomalous blood vessels, usually an artery and vein, which cross and change the angle of ureteropelvic drainage (Fig. 1), with possible interference of ureteral peristalsis by pulsation, as suggested by Quinby. Unless search is made for these vessels as they cross the ureteropelvic juncture, they are easily overlooked. With these vessels, it is usually found that angulation of the ureter at the ureteropelvic juncture by renal pelvic or perirenal pelvic connective tissue has occurred which, with dilatation of the renal pelvis, produces ureteral compression (Fig. 2). In some cases the absence of demonstrable obstruction in the presence of large hydronephrotic sacs suggests disturbances of neuromuscular control of the renal pelvis and upper part of the ureter.

ANOMALOUS VESSELS

If an anomalous vessel is compressing the ureter at the ureteropelvic juncture, thus changing its course and interfering with proper emptying of the pelvis, and if the additional blood supply is sufficient, I see no reason why the anomalous vessel should not be divided. I have divided it successfully in several cases; one case was that of a woman with polycystic kidneys, reported elsewhere. If, however, as a result of this type of obstruction, the extrarenal pelvis is considerably dilated, it is resected to within 1.5 centimeters of the renal substance, leaving the ureter attached to its dependent portion. Closure of this opening in the pelvis removes the hydronephrotic sac and changes the course of the ureter, and its opening becomes dependent. In the cases in which this was done, nephropexy was also done to prevent further ureteral angulation. In some cases temporary nephrostomy was done also, to relieve pressure on the suture lines. If for any reason there is a question of inadequate blood supply from the remaining vessels to the kidney, circulation in the anomalous vessels should not be obstructed, particularly if the opposite kidney shows any abnormality of function. Such obstruction existed in one of the cases in which there was a large hydronephrotic sac on both sides. In such cases the dilated extrarenal pelvis is resected, or the ureter is reimplanted into the dependent portion of the pelvis away from the anomalous vessels.

ANGULATION AND COMPRESSION OF THE URETER BY PERIPELVIC CONNECTIVE TISSUE

In several cases of hydronephrosis in which nephrectomy was necessary because the kidney was largely destroyed, compression angulation and obstruction of the ureteropelvic juncture occurred as a result of a dense sheath of connective tissue. This tissue apparently originates from the tissue of the renal pelvis; its congenital nature is suggested by postmortem observations in a child aged 17 days, whose death was the result of renal

[1]Submitted for publication April 22, 1930.

Fig. 1. Anomalous artery and vein of large size crossing and obstructing ureter at ureteropelvic juncture (arrow points to artery); ureter between artery and vein.

insufficiency caused by bilateral hydronephrosis, which in turn was due to such a connective tissue sheath. Division of this sheath, if the hydronephrotic sac is small, combined with resection of the renal pelvis if the sac is large, should be considered, provided sufficient renal parenchyma exists. If there is doubt in this respect and if the opposite kidney is normal, nephrectomy is the better procedure.

ABSENCE OF DEMONSTRABLE OBSTRUCTIVE LESIONS

Hydronephrosis, in the absence of demonstrable obstructive lesions, was present in 3 cases. One case in particular is noteworthy. The hydronephrosis was bilateral; each pelvis had a capacity of 150 to 175 cubic centimeters. A large anomalous artery and vein crossing the right ureter at

Fig. 2. Ureter obstructed by peripelvic connective tissue and by an obliterated anomalous renal vessel.

the ureteropelvic juncture presumably was the cause of the obstruction, whereas the left kidney, also hydronephrotic, and with the same capacity, did not show demonstrable obstruction at the pelvic juncture. The same operative procedure was carried out on both sides, namely, resection of the renal pelvis. This was followed by equally good results; there was no longer retention in either pelvis.

RESECTION OF THE HYDRONEPHROTIC RENAL PELVIS

I used this method of operation in the first case in which there was no demonstrable cause for the obstruction. The dilated portion of the left hydronephrotic pelvis was excised (Fig. 3) and the ureter was severed from the pelvis and reimplanted into its dependent portion (Fig. 4). Anastomosis was made with three rows of chromic catgut and protection of the suture line with a portion of peripelvic fat. On the tenth day after operation, stasis occurred with retention of a small amount of infected urine in the kidney. A ureteral catheter was inserted through the cystoscope for pelvic drainage (Fig. 5), following which satisfactory convalescence occurred. In the succeeding cases,

it seemed advisable to develop a method by which the hydronephrotic portion of the pelvis might be excised without entirely severing the ureter from it, in the hope that pelvic stasis would be prevented. Figure 6A shows the hydronephrotic pelvis being separated from the blood vessels of the renal pedicle. Figure 6C shows the pelvis excised to within 1 centimeter of the renal parenchyma; this changes the course of the ureter from a lateral insertion to a dependent one. Figure 6D shows the opening of the pelvis closed with chromic catgut in a manner similar to that described.

In the 3 last cases in which operation was performed, temporary nephrostomy has been found to be advantageous in that it removes tension from the anastomosis. An additional ureteral catheter is inserted, extending through the cortex and into the ureter. It serves as a scaffolding and a splint to promote healing without obstruction at the ureteropelvic juncture.

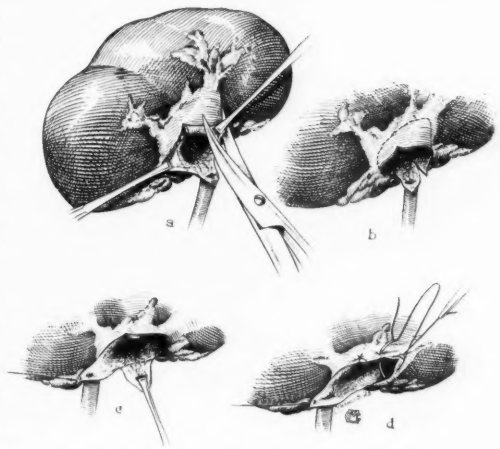


Fig. 3. Resection of hydronephrotic renal pelvis.

REIMPLANTATION OF URETER INTO DEPENDENT PORTION OF THE RENAL PELVIS (KUSTER-QUINBY)

Kuster and Quinby believe that removal of the ureter from its lateral attachment to the hydronephrotic renal pelvis and its reinsertion by suture to the dependent portion of the pelvis away from these anomalous vessels is indicated if the anomalous vessels crossing the ureteropelvic juncture are of such size and importance that their division and ligation seem inadvisable. Such a method was used successfully in one case (Figs. 7A and B). Inasmuch as the technique for this operation has been fully portrayed by them it will not be repeated here.

COMPLICATIONS

Anticipated postoperative complications seem to center around: (1) leakage of urine at the point of anastomosis with perirenal accumulation; (2) retention of urine in the kidney, leading to pyelonephritis or cortical abscesses in the kidney; and (3) ureteral obstruction at or below the pelvic incision with a persisting urinary fistula from the pelvic anastomosis.

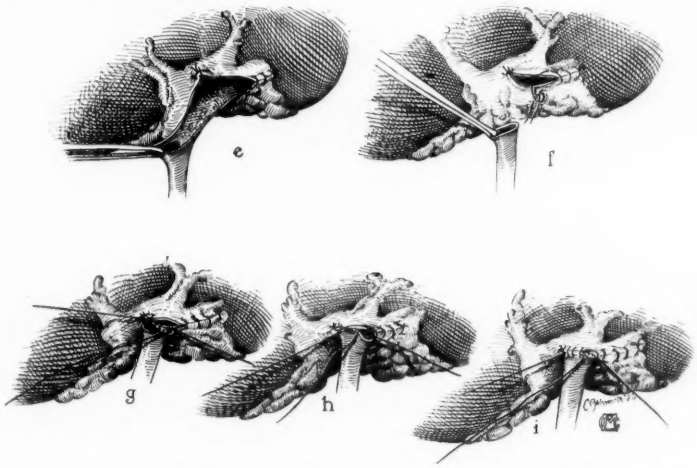


Fig. 4. Resection of hydronephrotic renal pelvis; reimplantation of ureter into dependent portion of pelvis.

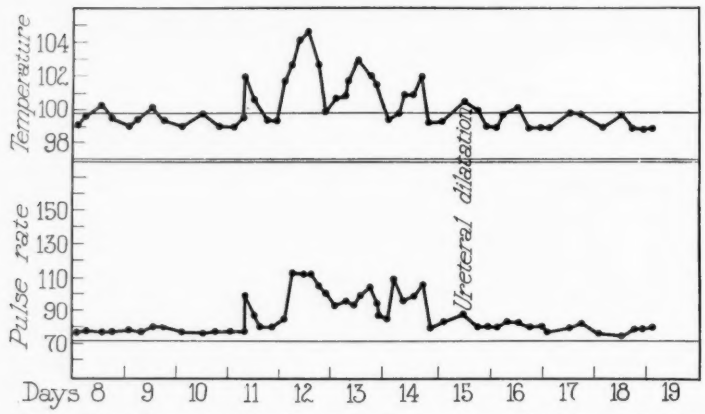


Fig. 5. Temperature chart showing effect of urinary accumulation in renal pelvis and its removal.

Accumulation of urine about the kidney in one case necessitated reopening of the incision and drainage of the perirenal space. Approximately 700 to 800 cubic centimeters of infected urine was evacuated. A study of the function of this kidney and a pyelogram made 2 weeks later, showed a practically normal kidney from which urine was being excreted in normal quantity and discharged into the bladder through the ureter. The function of this kidney was better than that of the other kidney; the excretion of indigocarmine was graded 2 (Fig. 8). When the patient was allowed to return home 2 weeks later, the incision had practically healed and drainage of urine had ceased.

RETENTION OF URINE IN THE PELVIS OF THE KIDNEY

In the first case in which operation was performed, retention of urine in the kidney manifested itself by cessation of drainage from the incision, chills and fever, on the tenth day after operation. A ureteral catheter inserted into the pelvis of the kidney withdrew 5 to 10 cubic centimeters of turbid urine. The fever subsided and the patient's recovery, although slow, was satisfactory (Fig. 5). This patient has recently begun to have trouble in the opposite kidney, and exploration of this kidney will probably be necessary at some future time. In the case in which the Kuster-Quinby technique was used, evidence of retention of the urine in the pelvis again manifested itself by fever. The retention was relieved and reaccumulation was prevented by allowing an indwelling ureteral catheter, which was inserted through the cystoscope, to remain in place. The catheter was kept open by frequent irrigation. The associated pyelonephritis was completely controlled by intravenous injections of neosalvarsan. This patient's progress subsequent to operation has been excellent; urine is no longer retained in the pelvis of that kidney (Fig. 4) and his general condition for more than 7 months has been excellent. In another case in which the general condition did not permit pyelographic study following resection of the renal pelvis, urine was seen to drain from the kidney which had been operated on through the ureter into the bladder on cystoscopic examination. Nevertheless, at times, the patient showed evidence of the presence of pyelonephritis, characterized by chills and fever. Finally, it was necessary to remove the kidney in spite of what appeared to be adequate drainage. Pathological examination of the removed organ showed diffuse pyelonephritis and small cortical abscesses.

OCCLUSION OF THE URETER WITH PERSISTING URINARY FISTULA

In another case it was necessary to remove the kidney secondarily to resection of the hydronephrotic renal pelvis because of a persisting urinary fistula, apparently caused by postoperative perirenal and ureteral infection occluding the latter. At the time of operation, it was noted that the sac was large, containing approximately 350 cubic centimeters of urine, and that the parenchyma of the kidney was half the normal size. The kidney was removed 50 days after the plastic operation; it weighed only 67 grams. The decision to attempt resection of the renal pelvis rather than nephrectomy probably was unwise because of the extreme

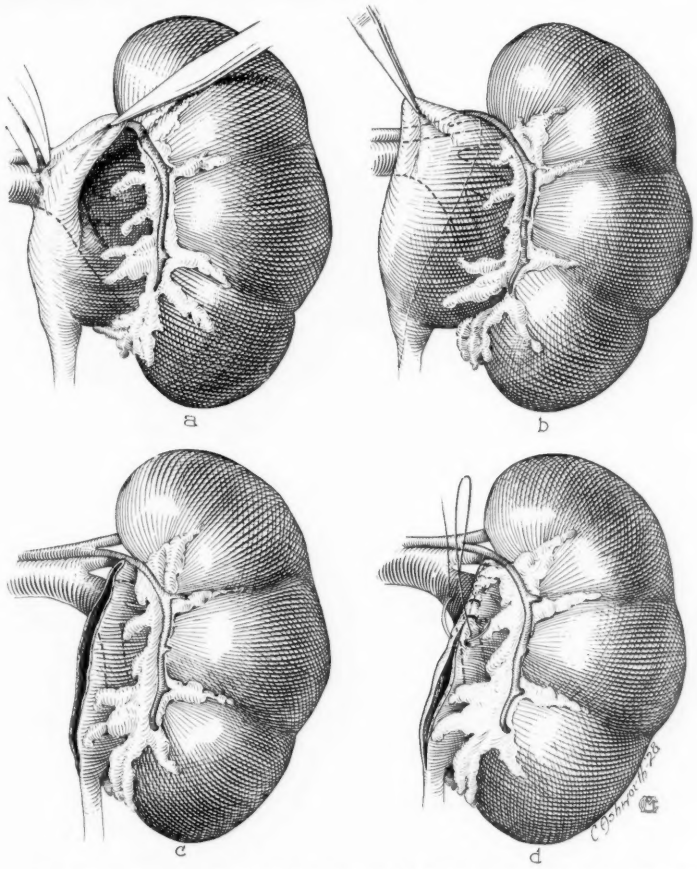


Fig. 6. Resection of hydronephrotic renal pelvis allowing ureter to remain attached.

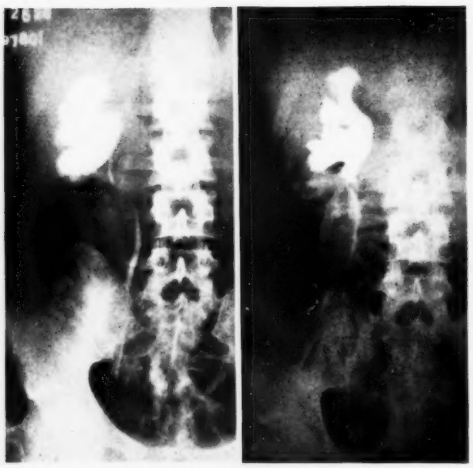
degree of hydronephrosis and the reduction in the size of the renal parenchyma.

SUMMARY

In 11 cases of hydronephrosis, resection of the renal pelvis was performed. In 8 cases (9 resections) the results of operation were excellent. In 4 of these cases hydronephrosis was bilateral, and the renal pelvis was large and infected. Bilateral resection was done in one case, with an interval of 3 months between operations, with excellent results. Practically 2 years have elapsed since these operations, and the patient has been completely relieved of all symptoms of renal retention or obstruction. This is probably the first successful case in which resection of bilateral infected hydronephrotic kidneys has been reported. In 3 additional cases of bilateral hydronephrosis successful resection of one hydronephrotic renal pelvis has been performed. Three months will elapse before the other renal pelvis is resected.

Cases of hydronephrosis in which successful results followed division of anomalous blood vessels, or connective tissue sheaths, are not included in this series of pelvic resections.

Three cases in which resection of the renal pelvis was performed required secondary nephrectomy due to (1) persistent urinary fistula from occlusion of the ureter by postoperative infection around the ureter, and (2) pyelonephritis with cortical abscesses in 2 cases in which urine was being transmitted successfully from the resected renal pelvis to the bladder through the ureter. Complete recovery followed nephrectomy.



A B

Fig. 7. A, Pre-operative pyelogram, B, postoperative pyelograms. Kuster-Quinby method used of reimplantation of ureter into dependent portion of renal pelvis.

Fig. 8. Pyelogram following resection of renal pelvis with urinary leakage from anastomosis necessitating drainage.

When postoperative stasis occurred in the renal pelvis, it was successfully relieved by the introduction of an indwelling ureteral catheter through the cystoscope, where it was retained as long as the retention persisted. In spite of leakage of urine from the anastomosis with perirenal accumulation, results may be satisfactory provided drainage is sufficient.

CONCLUSIONS

1. Resection of the hydronephrotic renal pelvis is an operative procedure worthy of consideration if there is sufficient normal renal parenchyma and if the function and condition of the opposite kidney is not entirely satisfactory.

2. Bilateral resection of bilateral hydronephrotic kidney, as was done in a case in this series, may be followed by excellent results. The postoperative complications, such as temporary accumulation of urine within the renal pelvis immediately subsequent to operation, leakage of urine from the pelvic anastomosis, and pyelonephritis if adequately controlled may not compromise the end-result of the operation of renal pelvic resection. Yet, if response does not occur, nephrectomy may become necessary and should not be too long delayed provided the opposite kidney is normal.

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TRANSPLANTATION OF THE HEAD AND SHAFT OF THE FIBULA TO THE HUMERUS

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THE only other case of transplantation of the head and shaft of the fibula to the humerus that I know of is the one reported by P. G. Skillern.[1] In Skillern's case the humerus was removed for sarcoma and the head and shaft of the fibula were used instead of the head and shaft of the humerus.

In the case discussed here we were dealing with non-union of a comminuted fracture of the humerus followed by a low grade type of osteomyelitis due no doubt to the various kinds of material used to hold the fracture in place to assist in the union of the two fragments of the humerus. We encountered considerable difficulty in keeping the fragments in apposition. Numerous trials at reduction were made but without success. Many types of splints in addition to plaster casts were used but we could not keep the fractured ends together. It required six open operations before we attained success. The various steps will be given in full as we relate the history of the patient. Briefly we used Parham bands on two occasions, a Sherman plate, a tibial bone graft, and finally the fibular graft. The patient now has a good arm, the flail arm being replaced by a firm one—which is useful although the range of movement is somewhat reduced as compared with the normal. There is also some radial nerve palsy which is mending slowly.

[1] Internat. Clin., 1920.

K. T., aged 50 years was admitted to the Jewish Hospital, February 25 and discharged March 15, 1927. She had slipped on a rug at the top of the stairs and fell, sustaining a fracture of the upper third of the left humerus (Fig. 1). Numerous trials at reduction were made but without success. An open operation was performed March 5. A Parham band was used with the result that the ends were in fairly good position (Fig. 2). No drainage was used. On February 25, the radiologist reported "a comminuted fracture involving about 4 inches of the upper portion of the left humerus and extending almost into the head of the bone."

Patient was again admitted May 24, 1927 and discharged June 21, 1927. No union was present 3 months after the injury. She had no pain but noticed that she could not use her arm. The left hand was partially paralyzed. The old scar was excised, many adhesions were separated and the humerus was exposed. The band was removed and in its place a Sherman plate was inserted (Fig. 3), and a plaster cast applied with the arm at an angle of 45 degrees. Union did not take place after this operation. It was with great difficulty that we persuaded the patient to submit again to operation.

She was admitted to the hospital the third time on February 28, 1928, and was discharged March 13, 1928. At this time the metal plate was removed and the ends of the bone were still ununited. They were freshened by

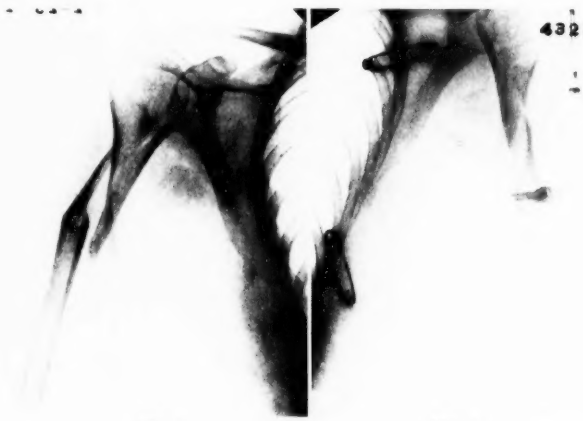

Fig. 1.

Fig. 2.

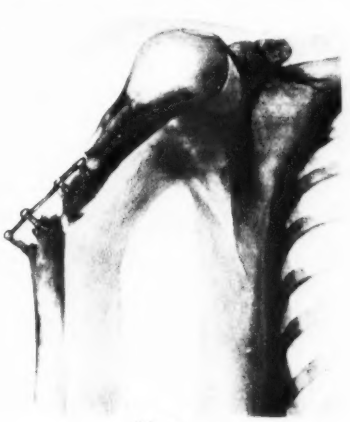

Fig. 3.

Fig. 1. Retouched roentgenogram of fracture immediately after the accident.

Fig. 2. Parham band in position. Used in first and fourth operations. Retouched photograph.

Fig. 3. Sherman plate which was used at the second operation and the result after the cast had been removed. Drawn from roentgenographic plate.

Fig. 4.

Fig. 5

Fig. 6.

Fig. 4. Bone graft from right tibia. The distal portion became firmly united. Non-union of upper part of graft. Drawn from X-ray film.

Fig. 5. Illustrates the removal of the head and shaft of the humerus on account of a low grade osteomyelitis.

An interval of 4 months followed before the fibular gra was used.

Fig. 6. Showing transplant of head and shaft of fibu to the distal end of the humerus. Drawn from X-ray fil A moving picture of this operation was obtained.

means of the Albee saw, and a bone graft taken from th right tibia was transferred to the arm (Fig. 4). The gra was held in position with kangaroo gut. Pathologica examination of a section of bone revealed considerab inflammatory tissue surrounding portions of the bone a the periphery with the blood vessels congested an fibrous tissue cystic at points.

After this operation there was union of the fragment but the patient did not agree with me. In a fit of anger sh broke the graft near the proximal end of the fracture. This loosened the graft in the proximal end of the bone, the graft in the distal portion being firmly united to i This was the condition of affairs found when she entere the hospital for the fourth time on May 29, 1928. A open operation was again performed, the old scar wa excised, the adhesions were separated around the humerus,

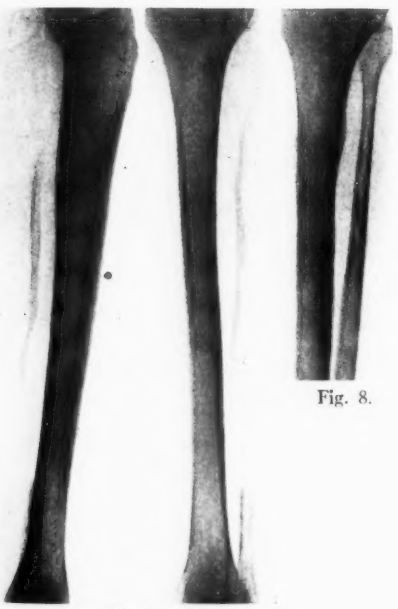

Fig. 7.

Fig. 8.

Fig. 7. Regeneration of the fibula. One year after operation.

Fig. 8. Regeneration of tibia 2 years after Albee bone graft.

Fig. 9. The result 1 year after operation.

and the graft was cleared of surrounding tissue. The lower fragment of the broken graft was firmly united, the upper fragment was lifted out of the wound. The ends of the fracture were again freshened. Great difficulty was now encountered with the upper fragment as nothing would hold in the degenerated softened bone. Bone pegs, bone screws, and bones were tried but all to no avail. Finally a Parham band was again applied so that the graft in the distal fragment would act as a splint to hold the upper fragment long enough to form callus. But no union occurred. Patient was discharged on June 3, 1928.

She was admitted for the fifth time November 15, 1928, and was discharged November 27, 1928. She complained for the first time of pain in the left arm, and inability to move it. She took the sun treatment all summer believing that this would help her to generate some callus. The old scar was again excised and the humerus exposed. This was found necrotic, especially at the ends of the bone. It was also found that the shaft of the humerus attached to the head was necrotic. The portion including the head was excised at the shoulder joint. Pathological report. Specimen consists of the head of the humerus and a small portion of the shaft. The articular surface appears normal. The bone itself appears exceptionally thin. It is partly transparent. The medullary cavity is rough and its contents are exceptionally friable. Section shows the bone undergoing destruction. Here and there are areas of round cell infiltration.

Although all preparations had been made to use another massive tibial graft it was thought advisable to allow the mild inflammatory condition to subside before attempting any kind of bone transplantation. This was concurred in by Dr. C. F. Nassau who was a spectator at the former operation and the next which happened to be the last (Fig. 5).

The patient was admitted the sixth time March 20, 1929, and was discharged April 3, 1929. Patient now complained of a flail arm. The old scar was excised and the arm was prepared for the fibular graft which I decided was the only logical method after the former operations. The distal two-thirds of the shaft of the humerus was found to be soft and decalcified. It was necessary to remove the shaft of the humerus to a point about 2 inches above the condyles. The glenoid cavity was cleaned to receive the head of the fibula.

An incision was then made along the lateral side of the left leg over the fibula. A segment of fibula, equivalent in length to the missing portion of humerus, was excised and transplanted to the left arm (Fig. 6). The end of the shaft of the fibula was gently tapped into the medullary cavity of the humerus. This made a perfect fit precluding the use of bone pegs or screws. The head of the fibula was snugly secured in the glenoid cavity. A few interrupted sutures of catgut in the deltoid muscle held the head of the bone in place. The arm once more was restored in continuity. A cast was applied with the arm at an angle of 45 degrees. X-ray examination on April 2, 1929, made through the cast revealed a long piece of bone extending from the shoulder joint downward to about 1.5 inches above the elbow joint. This bone appeared to be in excellent alignment with the lower end of the humerus. It is difficult to recognize any callus due to the irregularity of the shadow cast by the plaster.

It is now one year after the last operation which has been eminently successful. The fibula is firmly entrenched in the shaft of the humerus (Fig. 7). The head of the fibula moves freely in the glenoid cavity. The arm can be moved at will in all directions except that the arc of motion is not as great as formerly. This may partly be due to fear of breaking the arm.

INJURIES TO THE SEMILUNAR CARTILAGES OF THE KNEE JOINT[1]

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THE anatomical structure of the knee joint is of a more or less composite character, although chiefly of the hinge type. During action, there is a constant change of surface contact for weight-bearing between the femur and tibia not seen in true hinge joints, such as the elbow and the ankle. In the final part of extension, there is a certain amount of outward rotation of the tibia on the femur and in full flexion a certain amount of inward rotation. This departure from a true hinge-like action that has a broad surface contact is probably the chief cause of most of the derangements of the semilunar cartilages.

Injury to the semilunar cartilage is the most common cause of derangements of the knee. The internal and external semilunar cartilages occupy, respectively, the inner and the outer compartments of the knee, resting on the internal and external tuberosities of the tibia. They partially cover the articular surfaces of the tuberosities, and deepen the fossæ for the reception of the condyles of the femur; the internal cartilage covers less of the tibial articular surface than does the external. The latter is said to cover, occasionally, the entire surface of the external tuberosity. The two menisci are connected anteriorly by the transverse ligament, and, although the internal meniscus is firmly attached to the internal lateral ligament or capsule, the external cartilage is rather loosely bound to the capsule, but both are quite firmly attached posteriorly to the intercondyloid fossa. The coronary ligaments bind the cartilages to the tibial head and are at the periphery; they are intimately associated with the capsule and are of no importance surgically. The inner margins of the cartilages are free, making it possible for small foreign bodies, such as needles, to hide away under the meniscus. A fact not generally realized is that the semilunar cartilages are partly fibrous, and are more prone to rip or tear longitudinally in their substance than they are to fracture transversely, so that the term "torn cartilage" would in most instances be more apt than that of "fractured cartilage."

The internal semilunar cartilage is more frequently injured than the external, owing to the fact that if it is caught between the internal condyle of the femur and the head of the tibia and the act of extension is continued, it cannot slip out of the vise-like hold, because it is firmly anchored at its periphery to the internal lateral ligament. If the force continues, the cartilage generally rips in a longitudinal direction, remaining attached anteriorly and posteriorly, the loop thus formed slipping into the intercondyloid notch and producing the typical bucket handle fracture described by Morison. This is the most common type of tear and it is not confined to the internal cartilage. I have reported (7) 2 such tears of the external cartilage encountered in 76 cases of bucket-handle fractures. Three other cases have been observed since this report. Fagge recently expressed the opinion, and I am inclined to agree with him, that most of the tears and injuries of the internal cartilage are primarily of this variety and that further injury converts them into various other types. Basing the classification on observations at operation, I would divide the various injuries to the internal semilunar cartilages into four main types (Fig. 1).

1. A tag-like flap of varying size which is split off from the anterior portion and hangs free with its base attached to the posterior mesial portion of the anterior third (Fig. 1*a*).

2. The same type of pedunculated flap may be seen in the middle third of the cartilage, sometimes doubled back on itself and pointed posteriorly (Fig. 1*b*). This is a difficult type to see at operation, and one that may readily be missed. Such a flap may be worn into an ear-shaped tag attached by a rather small short pedicle. When caught, it causes sharp, severe pain, but is usually released readily if the patient gives a vigorous kick or two, and swelling or disability does not follow. I am confident that many times these ear-shaped tags are overlooked at operation because they are rather deeply situated, and not easily seen. In this event, the cause of the attacks is attributed to the more or less mythical fat tags that are removed.

3. The bucket handle or loop type of injury (Fig. 1*a*), which has been mentioned, causes the most constant symptoms, and generally is readily diagnosed.

4. A pedunculated flap, in the posterior third of the cartilage, gives rise often to bizarre symptoms. It is generally impossible to see anything of such a flap in this position, through an anterior incision, and it is not until the cartilage is removed

[1] Submitted for publication January 30, 1930.

r a posterolateral incision is made to explore the osterior portion of the cartilage, that the lesion discovered (Fig. 1*d*).

Apparently, injury to the semilunar cartilages s not seen in the United States with anything ke the frequency that it is encountered in Eng- nd. It has been my experience, on visiting ngland, that it is not unusual to see two or three emilunar derangements listed on the day's opera- ive schedule in certain of the larger clinics, most f the patients being miners, football players, or ugby players. The greater number of such de- angements, there, as compared to those occur- ing in America, may be explained by the fact hat in America the population as a whole does ot participate in the more active sports to the extent that the people of the British Isles do, and that coal miners here work in seams of greater height, permitting erect posture, instead of a cramped position with the knees partially flexed, so favorable to injury to a semilunar cartilage. The injury is always produced by indirect trauma, but not necessarily while the patient is engaged in an active pursuit, or while he is standing. I can recall one patient who had locking of the knees caused by typical bucket handle type of fracture of both internal semilunar cartilages at different times a few years apart, while he was in bed. The primary locking occurred in one knee when he was turning over in bed preparatory to arising; it occurred in the other knee in his sleep, and he was awakened by the pain. In several other cases, the attack occurred during the act of swinging around a newel post at the foot of a flight of stairs. However, the majority of injuries came about while the patient was playing some game or performing some task entailing consider- able strain on the knee joint. According to our series of 256 cases, as would be expected, there is a preponderance of persons in early adult life, with males predominating 4:1 (tabulation).

Most information on the subject of injury to semilunar cartilages has been gleaned from the British literature. However, of recent years, in- creased interest has been evidenced in the United States by various contributors (2, 3, 13, 15, 16, 17). A review of cases at The Mayo Clinic was undertaken in order to correlate the experience during a number of years. As so often happens when cases come to one's attention rather spo- radically, the continuity of clinical observations is interrupted and a review is necessary properly to evaluate the clinical signs. My chief reason for the review was that I found that joints were being opened occasionally, and it seemed to me too often, in cases in which the patients gave good

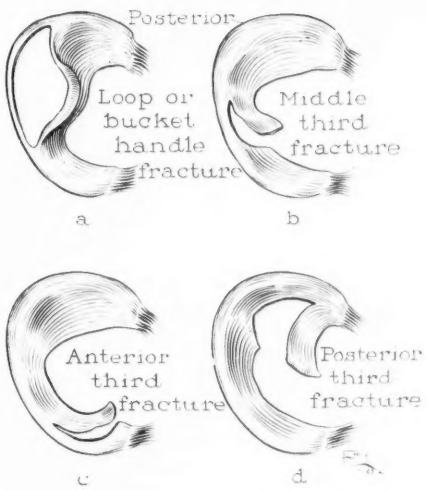

Fig. 1. Common types of fracture of internal semilunar cartilage.

clinical histories of injuries to the semilunar car- tilages, but who presented operative data that were put down as negative or insufficient to ac- count for the symptoms. An experience of this kind is exasperating, to say the least. The oppor- tunity for free and easy exploration of the cavity of the knee joint is by no means parallel with the opportunity to explore the abdominal cavity. It is clearly evident, therefore, that an exact diagnosis is most desirable in operating on the knee joint. I reviewed, with much interest, the records of 256 patients, from whom 261 cartilages had been removed. Five patients had had more than one cartilage excised. Many of the patients had been seen a considerable time after the opera- tion and the outcome had been definitely ascer- tained. The end-results concerning the others had been determined either by correspondence with the family physician or with the patients them- selves. The results are known in 238 (94 per cent) of the 256 patients.

SYMPTOMS

The symptoms in these cases are chiefly sub- jective; therefore, in industrial compensation cases one must be on one's guard. The patient's account of the actual happenings at the time of the original injury is often fogged, either because of the rapidity with which the various factors causing the injury occurred or because of lack of observation. Much interesting information may be obtained during the study of a group of his-

tories of this kind which cannot be readily tabulated, and the gleaner of such information must present in more or less arbitrary fashion the meat of his observations. In my grouping of cases, those called typical were those in which the primary injury to one of the cartilages occurred during more than usual activity, and it was characterized by pain in the knee, coming on suddenly, accompanied by immediate disability with inability to extend the knee (locking), and followed by swelling. Usually there ensued irregular attacks with greater or less effusion in the joint, complete return to normal occurring between the attacks. The exceptions, wherein normal function between attacks was not attained, were in most instances those cases of bucket handle fracture because, after the locking, the loop failed to slip back from the intercondylar notch and extension could not be completed, although all other signs, such as pain, soreness, and swelling, subsided. In the typical cases, the manner of production was also considered: the knee partially flexed, the foot everted, and the strain clearly on the internal lateral ligament. Of 234 patients with derangements of the internal semilunar cartilage, 179 (76 per cent) gave typical histories. Of 22 patients with derangements of external cartilages, 14 (63 per cent) gave typical histories. More will be said of injuries to the external cartilage later in the paper. In comparatively few cases was there an opportunity to see the patient at the time of the original injury. The average length of time elapsing from the time of onset until operation was 3.76 years; the extremes varied from a few weeks to many years.

DIAGNOSIS

The diagnosis is not always easy. Kleinberg suggested the use of oxygen inflation and roentgenological examination, since it is possible to outline the menisci by such means. Kreuscher has suggested the use of an instrument similar to the cystoscope, which he called the arthroscope, but he did not report on its use. The roentgenray, unless oxygen inflation is employed, is useless; the meniscus does not cast a shadow, except in rare instances in which calcification has partially occurred. I have not used the oxygen inflation method and cannot, therefore, speak of its value.

The main points to be considered in the diagnosis are: (1) injury to the knee, generally indirect and sustained usually during some active pursuit, and (2) recurrent attacks with intervals of complete freedom both subjectively and objectively. The attacks are characterized by pain, disability, swelling, lack of complete extension, a feeling of something amiss in the joint, and usually some tenderness (if the injury is to the internal cartilage) over the anterior border of the internal lateral ligament at the joint line. In cases in which the external cartilage is the seat of the injury, the pain and tenderness are usually referred to the outer side.

The pain accompanying the injury is sudden and may be excruciating, completely disabling the patient. Rarely is it definitely localized, but the patient will usually state that it is in the anterior part of the joint and mostly on the inner side. When the external cartilage is at fault, the pain, as has been mentioned, is referred to the outer side of the knee and often posteriorly as well. Because of lack of any large series of cases of injury to the external cartilage, however, definite data are not afforded. In this series there were 22 injuries (roughly 8.6 per cent of the total) or 1 injury of the external cartilage to 12 injuries of the internal cartilage. As the attacks recur and increase in frequency, the pain may not be so severe. Pain was present in all the cases in this series.

The swelling which comes on immediately after the attack is due to synovial effusion and is probably protective in character. Occasionally, hæmorrhage into the joint is encountered, but it is rarely of any significance. Periarticular thickening is not present, except that which occasionally is felt along the attachment of the internal semilunar cartilage to the capsule at the site of the injury. As the attacks become more frequent, the subsequent effusion is less in quantity and disappears more quickly. Swelling was mentioned in 224 (87 per cent) of the cases.

Inability completely to extend the knee was noted in 101 (39 per cent) of the cases at the time of examination. In most of these a bucket handle fracture was present with the loop caught in the intercondylar notch.

In the 234 cases of injury to the internal semilunar cartilage, it was recorded in 181 that the injury occurred in flexion, but in 11 cases the patient stated that the injury was sustained with the knee in the extended position. I am inclined to believe that the latter is too high an incidence and that closer questioning might have cut down this number considerably. In the remainder of the cases, the records with regard to the injuries were indefinite. Localized tenderness is usually present over the anterior attachment of the internal semilunar cartilage if a tear of the bucket handle type is present, and particularly if the loop is caught and held in the intercondylar notch.

In chronic cases of this type, when the swelling has all disappeared and lack of extension is still persistent, palpation of the triangular area bound by the margin of the internal condyle, the tuberosity of the tibia, and the patellar ligament, will often disclose thickening. Although the patient may be aware of a feeling of insecurity in the knee, lack of extension may be appreciated by the patient only when he is told to stand erect with the feet even, and force back both knees into complete extension. It can then be readily seen that the affected knee does not go back as far as the normal one. A distinct localized swelling, often fluctuating, may be a cyst of one of the semilunar cartilages. These are said to be more common in the external cartilages. Allison and O'Connor published reports of 3 cases. Phemister has also written concerning them. In this series one external cartilage was removed on account of a cystic condition. I have seen a number of other cases in which the slight symptoms did not seem to warrant surgical intervention.

Habitual or recurring dislocation, throwing the knee out, catching, and locking are all terms used by the patient in describing the recurrent attacks. The number of lockings will vary from a few to a hundred or more. No doubt in strong vigorous men, particularly athletes, it is possible for the violent destructive action of the oft-repeated force to so fragment the semilunar cartilages that the offending tag or portion causing the locking is disintegrated and ultimately absorbed.

The differential diagnosis may be difficult in certain cases in which the history is not typical. Many patients complain of a mild catching sensation in the front part of the knee referred to the inner side. Fisher stated the belief that the tag-like prolongation of the infrapatellar fat pad is responsible for many of these, and advised manipulation followed by re-education of the quadriceps muscle. I have had no experience with this type of case, but it is probable that many useless explorations have been done on account of these indefinite symptoms. The various types of arthritis, specific and non-specific, may be difficult of differentiation. In arthritis there is often more than one joint involved and there is also periarticular thickening, and its presence in a suspected case should be sufficient to put the surgeon on his guard. Loose osteocartilaginous bodies produce locking that is more transient in character; appreciable swelling rarely follows and roentgenograms will disclose the offending bodies. A knee joint should not be opened until a satisfactory roentgenogram has been made, unless circumstances do not permit such a procedure. Early in the course of osteochondritis dissecans, especially if it occurs at adolescence before the line of demarcation or cleavage of the body is established and the area is really loosened so that it will show in the roentgenogram, the patient complains of a feeling of instability or insecurity in the knee. Carefully taken anteroposterior roentgenograms with slight flexion of the knee, and lateral roentgenograms, will often show a suspicious-looking area on the internal condyle proximal to the insertion of the posterior crucial ligament. Sir Robert Jones and Sir Arbuthnot Lane, years ago, called attention to the fact that tuberculosis of the knee seemed to occur in some cases in which symptoms suggesting injury to the cartilage had been present. I am inclined to believe that the swollen, congested synovial membrane, the result of arthritis, may have caused symptoms akin to mechanical derangement. I have never known tuberculosis to occur in a knee in which a definite lesion, such as a fractured cartilage, was found.

SURGICAL PROCEDURES

If repeated locking has occurred, or if the complaint cannot be relieved in primary cases by manipulation, and the condition is causing inconvenience to the patient, other things being equal, there is no reason for withholding the benefits of operation, and the offending meniscus should be removed. General anæsthesia is favored in The Mayo Clinic and is commonly used, but the operation can be carried out under local anæsthesia by the infiltration method about the knee or a combined caudal and spinal injection. The latter has the advantage over the infiltration method as it permits the use of the tourniquet.

The patient should be placed on the operating table so that the bend of the foot-piece of the table comes directly under the knee. Previous preparation is not necessary, other than a general bath and shaving of the affected knee. Benzine and iodine are applied with the leg elevated, and the skin is cleaned. The knee is held in the flexed and in the extended positions so that the wrinkles in the skin will be cleaned. Too vigorous preparation by scrubbing and poulticing may readily irritate the skin. A tourniquet is applied to the middle of the thigh, and the draping is carried so that the covering of the leg and foot is sterile. The foot of the table is dropped and the leg falls with it. The operator sits on a stool high enough so that he may hold the foot between his own knees, that are draped with a sterile sheet. This enables him to evert and invert the leg at will and still use both hands.

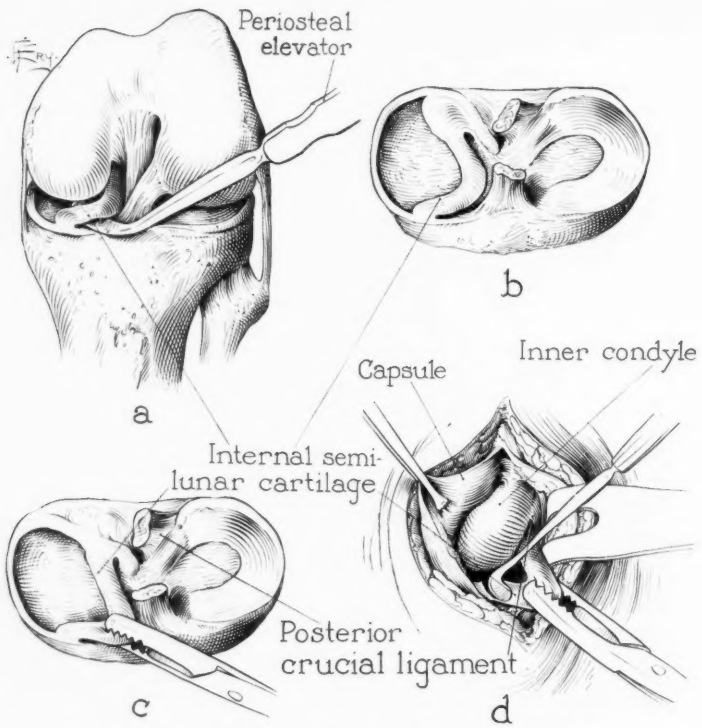

Fig. 2. *a*, Bucket handle fracture of the internal semilunar cartilage, showing its relationship to the head of the tibia and the condyle of the femur; periosteal elevator lifting up the cartilage; *b*, diagrammatic representation of position assumed by bucket handle fracture on the head of the tibia; *c*, Martin forceps grasping the cartilage; *d*, knife cutting anterior attachment.

A straight incision is made about 1.5 or 2 centimeters to the inner side of the patellar tendon, starting at about the level of the middle of the patella and extending downward to just below the level of the head of the tibia. Such an incision is far enough back to be convenient and still not injure that portion of the capsule known as the internal lateral ligament.

Galeazzi has called attention to the frequency with which injury to the crucial ligament is associated with injury to the semilunar cartilage. I am inclined to believe that in cases in which instability of the knee follows operation, the crucial ligaments have been injured at the time of the accident in a large percentage of cases and that too often the instability is attributed to injury to the internal lateral ligament at the time of operation. Although I question the importance of the internal lateral ligament in this rôle, I do not mean to infer that the ligament should be roughly handled or severed. The nearer the incision is made to the juncture of the anterior with the middle third of the cartilage, the better the opportunity to examine and remove the internal meniscus. By careful maneuvering and manipulation of the internal cartilage after it is loosened in front (Fig. 2) practically the entire cartilage can be removed through a small antero-internal incision (Fig. 3). If a definite lesion cannot be found in the portion that has been removed but the symptoms have been definite, the posterior portion of the cartilage should be removed, through a postero-internal incision. Care should be taken in separating the cartilage from the internal capsule not to cut into the substance of the capsule, or its function as an internal lateral ligament will be interfered with. It is best to leave a little of the cartilage attached, cutting through the substance of the meniscus itself just at the periphery; a knife designed by Frieberg is of assistance and the various

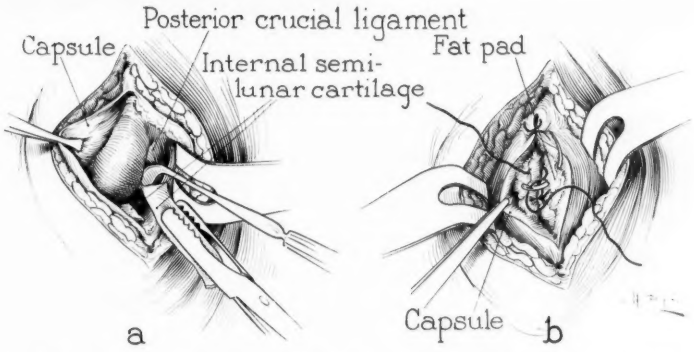

Fig. 3. *a*, Meniscus pulled forward in the intercondylar notch, and the posterior extremity being divided with Frieberg's knife; *b*, the wound sutured in layers.

types of scissors and snares used for certain nasal operations often facilitate the removal.

The wound should be closed after the tying of any vessels that can be seen in the periarticular structures, and the tourniquet is removed after a cotton dressing has been applied and firmly held by a bandage. Either a plaster cast or a posterior splint is put on and left for about 5 days, but it must be remembered that prolonged fixation prolongs convalescence. On its removal, the patient is encouraged to move the knee. In 8 days the stitches are removed and walking is encouraged, the contra-indication being too much effusion. Rarely is it necessary to perform aspiration; some effusion is to be expected. Physiotherapy as a postoperative procedure is not carried out as a routine in the clinic, since it rarely appears to be necessary, for the patients are usually young and vigorous, and full function is quickly regained.

When a fracture is found in a meniscus, there can be no doubt about the necessity of removing it. If the fracture or tear is in the anterior three-fifths of the cartilage, one is justified in being satisfied with the removal of that portion, but if the tear is in the back part it is not sufficient and the entire cartilage should be removed.

If a lesion is not found in the meniscus, but the symptoms have been definite, there being no doubt about the lockings and the pain referred to the inner side of the knee, it is best to remove the cartilage. In a number of instances, such a procedure has been proved to be justifiable by the finding of a pedunculated flap which could not possibly be seen through an anterior incision. Blind work and too vigorous or ill directed work from in front in the effort to loosen completely an internal cartilage with a bucket handle fracture lying in the intercondylar notch may result in severing one of the crucial ligaments. In a considerable number of cases in which attacks of locking had occurred for many years, it was a satisfaction to note, on the pre-operative record, that considerable laxity of the joint was present, for although the attacks of locking were relieved after removal of the meniscus the laxity persisted. Undoubtedly, many patients who report dissatisfaction following removal of a cartilage due to a lax knee have such a condition before operation, but all attention being focused on the cartilage, no attention is paid to it and so no record is made of the instability. The disability must be considerable to warrant any of the procedures recommended for reconstruction of the crucial ligaments.

RESULTS

Results for all cases. As I have stated 238 of the 256 patients (94 per cent) have been traced. One hundred eighty-three (77 per cent) are relieved of all trouble, 34 (14 per cent) are improved, and 21 (9 per cent) are not improved; thus, 91 per cent were cured or markedly improved. The 9 per cent of patients not improved are confined to the border-line group in which the complaint is sufficient to warrant surgical procedures, and although the clinical diagnosis was by no means clear-cut, it was thought best, in view of the safety of modern surgical procedures, to explore the knee. There have been no fatalities in the series, and no infection more serious than a low-grade skin infection in a few of the cases. It must never be lost sight of that infection is a possible risk, and the question so often asked by the patient advised to have an operation on the knee as to whether or not the letting out of the "joint water" will or will not result in a stiff knee bears

testimony that the lingering illness and often amputation or death that follow infection of the cavity of the knee joint has been indelibly impressed on the mind of the laity. The knee joint should be opened with the same rigid attention to technique that should be employed in any major surgical procedure; less care certainly cannot be countenanced. Knee joints should not be opened in offices and homes.

Results for cases in which pathological change was not demonstrable. In the series of cases under consideration there were 42 cases in which, at the time of operation, the operative note stated that the lesion present was not sufficient to account for the patient's symptoms, but that because of the definite subjective symptoms the meniscus was removed. These cases are most interesting. Seven patients, 6 with lesions of the internal cartilage and 1 with a lesion of the external cartilage were not traced; thus 35 patients were traced. Thirteen (37 per cent) were cured, 8 (23 per cent) were improved, and 14 (40 per cent) were not improved. It is my hope that with the advantage of more experience in diagnosis this group will be smaller from now on. It is clear, however, that in spite of the absence of a demonstrable fracture or tear in the cartilage, cure does result in more than a third of the cases comprising this group that have been designated as without sufficient evidence of a lesion to account for the symptoms. It is justifiable, I believe, to deduce from these data that some cases present definite symptoms of derangement, in which the condition is probably merely hypermobility of the cartilage.

SUMMARY

An accurate diagnosis is essential before operation is performed on the knee joint because a free and satisfactory exploration of the cavity of the knee cannot be carried out. The results of this type of surgery are good. Seventy-seven per cent of the patients operated on recovered completely and were free of all trouble. Injury to the crucial ligaments sustained at the original injury may give a certain amount of permanent laxness to the joint that should in no way be attributed to the results of operative procedures on the menisci. The cures following removal of the external semilunar cartilage did not quite equal those obtained by removal of the internal cartilage. The percentage of cures is reduced by the inclusion in the group of cases in which a definite lesion was not found at operation; in this group there were only 37 per cent of cures.

AGE AND SEX INCIDENCE[1]

Age, years	Patients
10 to 19	27
20 to 29	116
30 to 39	66
40 to 49	37
50 to 59	9
60 to 69	1

[1] There were 213 males and 43 females; 219 patients (86 per cent) were between the ages of 20 and 50.

The most common fracture or tear found was the bucket handle or loop type, 86 in the internal cartilage and 5 in the external cartilage; these fractures constituted more than a third of the series. This occurrence is higher than is found in most published statistics. In 78 per cent of the series, a fracture or a tear, or a distinctly loose cartilage was present.

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THE MECHANISM OF GLUTEAL GAIT

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THE residual paralyses of anterior poliomyelitis are as a rule erratic in distribution and not uncommonly an isolated paralysis of a single muscle may be observed. A single isolated paralysis of the tibialis anticus muscle with resulting talipes valgus deformity occurs relatively frequently. Paralysis of the gluteus medius muscle is often associated with other paralyses but it is unusual to observe disability of locomotion resulting from paralysis of this muscle only. This condition has been noted but once in our clinic during the past 5 years, during which time more than 600 patients with residual paralyses of anterior poliomyelitis have been studied. Paralysis of the gluteus medius muscle associated with other paralyses often results in a deformity and disability which must be considered minor as compared with the deformities and disturbance of function from the associated paralyses. A paralytic spine, knee, or foot as a rule demand treatment in preference to the deformity resulting from paralysis of the gluteus medius. An isolated paralysis of the gluteus medius muscle however, results in a relatively more important disturbance of locomotion and, as is demonstrated in the case reported in this paper, the resulting disability may be greatly improved by surgical treatment.

The origin of the gluteus medius is from the lateral surface of the ilium between the iliac crest and posterior gluteal line above and the anterior gluteal line below. It also arises from the gluteal aponeurosis covering its outer surface. The fibers converge to a strong flattened tendon which is inserted into the lateral surface of the greater trochanter. The muscle is partly covered by the gluteus maximus muscle and conceals the gluteus minimus muscle. It receives its innervation through the superior gluteal nerve from the sacral plexus (fourth and fifth lumbar and first sacral).

The gluteus medius is the chief abductor of the hip and is of special importance in supporting and balancing the pelvis when the patient stands on one foot. When a normal individual stands on one foot and flexes the opposite thigh on the abdomen, the pelvis remains either on a horizontal plane or is slightly elevated on the side on which the knee is flexed (Fig. 1). But if the integrity of the gluteus medius is impaired and cannot successfully oppose the force of gravitation, then the equilibrium of the pelvis is lost and the pelvis will drop on the side on which the knee is flexed (Fig. 2). The dropping of the pelvis on the affected side when one stands, can be observed by noting the relative levels of the buttocks. This observation is known as Trendelenburg's sign and occurs when the function of the gluteus medius is impaired, and in cases in which the mechanics of the hip joint are deranged as in congenital dislocation of the hip, ankylosis of the hip in adduction, sciatic scoliosis, and coxa vara. Impairment of the gluteus medius muscle function, either by paralysis or loss of the fulcrum on which it acts (Fig. 3) with resulting loss of stability and dropping of the pelvis, alters the center of gravity of the body in relation to the base of support. In order to maintain balance and equilibrium when standing on the affected side, the patient must list the trunk toward the affected side in order to have the center of gravity fall over the center of the base of support (Fig. 7). The list toward the affected side is repeated with each step and the patient walks with a "gluteal gait."

The "gluteal gait" is also observed in congenital dislocation of the hip. Following reduction of a congenitally dislocated hip the distance between origin and insertion of the gluteus medius muscle is returned to normal. The muscular function is re-established and with the femoral head within the acetabulum there is a firm fulcrum on which the gluteus medius can effectively balance the pelvis and successfully oppose gravitation. The dropping of the pelvis and the "gluteal gait" gradually disappear after the child becomes ambulatory following the reduction and restoration of the mechanics of the hip joint.

Spontaneous dislocation of the hip occasionally complicates paralysis of the muscles controlling the hip joint (Fig. 5). The mechanism of the production of spontaneous dislocation of the hip joint is a derangement of the normal action of the muscles surrounding the hip joint. The derangement may result from the residual paralyses of anterior poliomyelitis affecting the muscles of the hip joint controlling abduction (gluteus medius) and extension (gluteus maximum). The normal unopposed flexors and adductors undergo contracture and the involved extremity is held in the position of instability (flexion, and adduction) which results in dislocation. The case here reported presented a paralytic subluxation of the

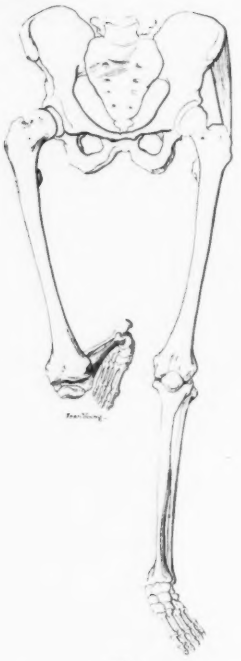

Fig. 1.

Fig. 1. Balancing the pelvis when standing on one extremity depends on a firm fulcrum provided by the femoral head within the acetabulum and normal function of the gluteus medius muscle.

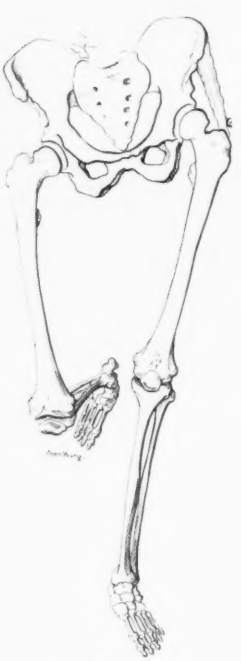

Fig. 2.

Fig. 2. Impairment of gluteus medius function results in dropping of the pelvis when patient stands on the affected extremity since the gluteus medius muscle cannot successfully oppose the force of gravitation.

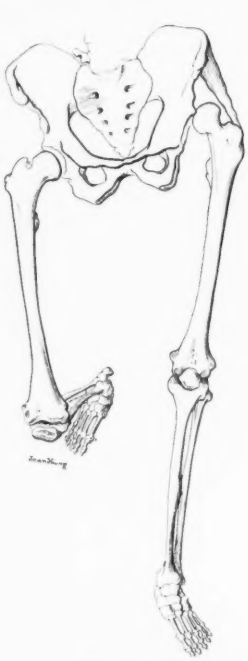

Fig. 3.

Fig. 3. Impairment of function of the gluteus medius muscle, either by paralysis or loss of the fulcrum on which it acts, results in a dropping of the pelvis when patient stands on the affected side.

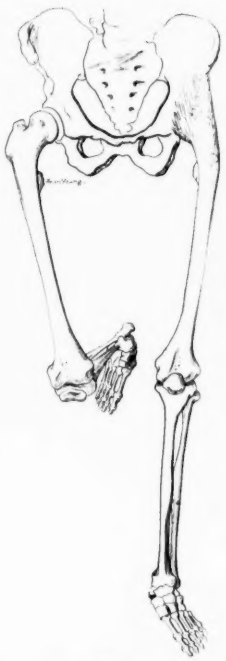

Fig. 4.

Fig. 4. Bony ankylosis of the hip joint in the optimum position for function stabilizes the pelvis in relation to the extremity and prevents dropping of the pelvis and a list of the trunk when patient stands on the involved extremity.

femoral head; however, only the abductor (gluteus medius) was paralyzed. It may be assumed that the gluteus maximus was partially paralyzed at the onset with subsequent restoration of function or that contractures of the adductor muscles resulted in a flexion adduction deformity. Subluxation of the femoral head results in dropping of the pelvis on the unaffected side when patient stands on the affected side, since the firm fulcrum on which the gluteus medius acts is lost. The local paralyses about the hip joint are as a rule associated with paralyses disturbing stability and mobility of the knee and foot; also abdominal paralyses with resulting spinal curvature and paralyses of the muscles of the upper extremity may be present. The associated deformities may be more serious lesions than the subluxation of the hip making the campaign of treatment a complicated problem in certain cases.

Since the "gluteal gait" in our patient was secondary to the dropping of the pelvis and a shifting of the center of gravity, it was clear that any attempt to improve the gait must necessarily re-establish the stability of the pelvis in relation to the affected extremity. It was thought that fusion of the hip joint in the optimum position for ankylosis would gain the desired stability between the pelvis and the extremity (Fig. 4). This reasoning could be fairly accurately tested by the application of a short plaster-of-Paris hip spica encasing the pelvis and thigh of the affected extremity. Accordingly, the spica was applied and the improvement of the patient's gait justified surgical treatment to obtain bony ankylosis of the affected hip in the optimum position for function. This was accomplished by means of an intra-articular and extra-articular fusion of the hip joint (Fig. 6), with the result that the patient

Fig. 5. Roentgenogram showing paralytic subluxation of the left hip, secondary to gluteal paralysis.

Fig. 6. Roentgenogram showing bony ankylosis of the left hip in the optimum position for function following intra-articular and extra-articular fusion.

is now ambulatory with a most gratifying improvement in her gait (Fig. 8). In this case we have demonstrated that a stable hip ankylosed in the optimum position for function is a better functional hip than an unstable one and that by opposing the effect of gravitation the gluteus medius muscle and the fulcrum on which it acts play an important rôle in balancing the pelvis when patient stands on one leg. Impairment of the function of the gluteus medius muscle affects posture, locomotion, and the support of the pelvis, as manifested by the list of the trunk, the "gluteal gait," and the Trendelenburg sign, respectively.

CASE REPORT

C. D., white, female, aged 19 years, was admitted to the Orthopedic Clinic, March 3, 1929. Her chief complaint was a pronounced list of the trunk toward the left side when walking or while standing on the left foot. The patient had infantile paralysis at the age of 13 months. The paralyses involved both lower extremities. There was a gradual restoration of muscle function with a complete return of function of the right lower extremity but an incomplete return of function of the left lower extremity. The patient's past history was otherwise unimportant. The general physical examination was essentially negative except for the muscular and skeletal systems.

The patient walked with a marked left gluteal gait. Standing on the left lower extremity caused dropping of the pelvis and a lowering of the gluteal fold on the right. In order to maintain balance while she stood on the left lower extremity the trunk listed markedly to the left. There were no paralyses of the upper extremities. The anterior and lateral abdominal muscles were normal except for a weakness of the right lateral abdominal muscles which functioned against gravity. It is possible that the partial paralysis of the right lateral abdominal muscles influenced the degree of list of the trunk to the left. The muscles of the right lower extremity were normal except for a complete paralysis of the tibialis anticus muscle which resulted in a mild talipes valgus deformity and hyperextension of the great toe secondary to overaction of the extensor hallucis longus muscle. Examination of the muscles of the left

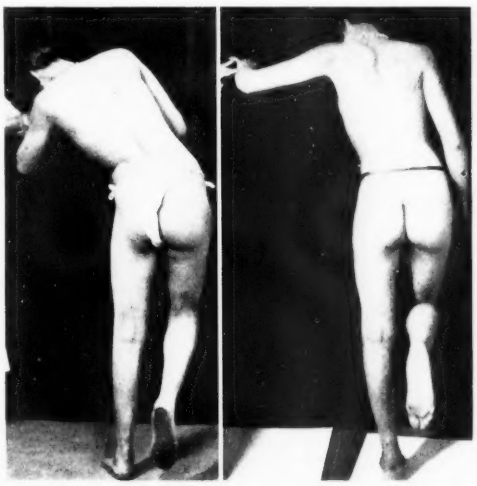

Fig. 7, left. To maintain balance and equilibrium with dropping of the pelvis, the patient must list the trunk toward the affected side in order to shift the center of gravity of the body over the center of the base of support. The list toward the affected side is repeated with each step and the patient walks with a gluteal gait.

Fig. 8. Following arthrodesis of the hip joint in the optimum position for function, the list of the trunk and gluteal gait were markedly improved.

lower extremity revealed a total paralysis of the gluteus medius muscle. The left tensor fascia femoris muscle was normal. The remaining muscles controlling the hip joint were weak; however, the rotators, extensors, flexors, and adductors functioned against gravity. The muscles controlling the knee joint were weak but all functioned against gravity and resistance. The muscles controlling the foot were normal. Examination of the left hip joint revealed free painless range of motion in all directions except abduction. The femoral head could be palpated posteriorly and there was mild telescoping. There was a moderate contracture of the adductor tendons and a scaphoiding of Scarpa's triangle. The left lower extremity was three-quarters of an inch shorter than the right. Radiographic studies of the pelvis and hip joints demonstrated a partial dislocation of the left femoral head from the acetabulum, coxa valga, and retarded development of the acetabulum, femoral head, and femoral shaft.

The application of a short plaster-of-Paris hip spica encasing the pelvis and left thigh in the optimum position for fixation of the hip joint resulted in a marked improvement of the patient's gait. On April 27, 1929, an intra-articular and extra-articular fusion of the left hip joint was performed. The left hip joint was immobilized by means of a plaster-of-Paris spica in a position of 30 degrees, flexion, 10 degrees, abduction, and neutral as to rotation. Bony ankylosis between the pelvis and femur resulted with the hip joint in the stated position. There was half an inch apparent shortening. Ankylosis of the hip joint resulted in a most satisfactory improvement. The patient now walks with a very mild list of the trunk to the left and complains of practically no discomfort or disability while sitting.

A STUDY OF HYPERTROPHIC OSTEO-ARTHRITIS OF THE SPINE[1]

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ARTHRITIS of the spine, particularly the hypertrophic form, is a frequent lesion in individuals past the fourth decade. Many writers consider the condition productive of nerve root pressure disturbances variously called radiculitis, neuritis, and intercostal neuralgia. In an attempt to determine the frequency of hypertrophic arthritis and associated nerve root involvement, a study was made of 80 cases, patients over 40 years of age, who presented themselves with a wide variety of complaints. The group was limited to those beyond the fourth decade because of the recognized greater frequency of osteo-arthritis at that period of life, and presented a small cross-section of that age period. Forty-five admissions were on surgical and 35 on the medical service. The majority were railroad employees, who belonged to the laboring class. The group comprised 74 males and 6 females. The average age was 52.4 years; the oldest being 75 and the youngest 40 years.

The frequency of hypertrophic osteo-arthritis of the spine has been reported in few instances. The lesion is regarded as a common finding. Garvin, in a series of 2,090 patients more than 50 years of age, in whom roentgenograms of the kidneys, ureters, and bladder were taken, found hypertrophic arthritis of the spine in 67 per cent of the males and 40 per cent of the females. Homman reported a group of 16 carefully studied cases of arthritis of the spine in which the hypertrophic form was present in 75 per cent. In this unselected group of 80 individuals, 44 patients or 55 per cent showed an osteo-arthritis ranging from very early to very advanced types of the Marie-Strumpell variety.

The incidence of the lesion according to the age period is shown in Figure 1. Wallace states that the youngest was 27 years of age while the average age was over 40 years. The average age in Homman's report was 49 years. The average in this series is 55.6 years. Since the majority of cases were in males no conclusions can be given as to the relative frequency in the sexes. Dickson states that 75 per cent of his cases occurred in males.

Osteo-arthritis in my series was found most often in the dorsolumbar region (Fig. 2). The cervical spine was not routinely roentgenographed. Of the 44 cases, both the thoracic and the lumbar vertebræ were involved in 21, 47.7 per cent; the lumbar alone in 16, 36.3 per cent; and the thoracic alone in 7, 15.7 per cent. The third and fourth lumbar and the two lower thoracic vertebræ were most commonly affected. The fourth lumbar was most often involved (23), 52.2 per cent; the third lumbar next (21), 47.7 per cent; following which the twelfth thoracic (21), 47.7 per cent; and eleventh thoracic (20), 45.4 per cent, showed the changes. Next in frequency were: second lumbar in 18, 40.0 per cent; first lumbar in 17, 39.6 per cent; fifth lumbar in 14, 31.3 per cent; tenth thoracic in 13, 29.5 per cent; ninth thoracic in 6, 13.6 per cent; and eighth thoracic in 3, 6.8 per cent.

The etiology of the condition has never been satisfactorily explained. A wide variety of causes has been assigned. Gonorrhœa, typhoid fever, infection of the teeth and tonsils, gastro-intestinal disorders, nasal sinus disease, faulty metabolism, and exposure to heat and cold have all been designated as factors.

Focal infection as a cause has received major consideration. Homman reported that the majority of cases examined showed oral infection in the teeth or tonsils or both. Garvin found 72 per cent of his cases had peri-apical infection, and, including these with pyorrhœa, 94 per cent had dental sepsis; 15 per cent of the women and 20 per cent of the men showed tonsillar sepsis; 75 per cent of the 39 men had prostatic infection. In this series, focal infection, chiefly of the teeth, tonsils, sinuses, and prostate was found in 45, 56.3 per cent, of the 80 cases examined. Thirty of the 44 (68 per cent) of the cases having osteo-arthritis had focal infection; in 15, 18.7 per cent, focal infection was present but no osteo-arthritis was found.

Attempts have been made to identify a specific bacterium of which the streptococcus has been the principal organism studied. Poynton and Payne were the first to show experimentally the infectivity of acute rheumatic fever. Beattie and Yates demonstrated that streptococci cultured from cases of acute rheumatic fever caused arthritis in rabbits. Others have described streptococci associated with acute and chronic arthritis variously as streptococcus viridans, streptococcus anhæmolyticus, and streptococcus non-hæmolyticus. Recently, Small has described a non-hæmolytic streptococcus, isolated from acute rheumatic fever and selected arthritis cases. He later published the results of treatment of these cases with a spe-

[1]Submitted to University of Pennsylvania Post Graduate School in partial fulfillment of requirements for degree Master of Medical Science.

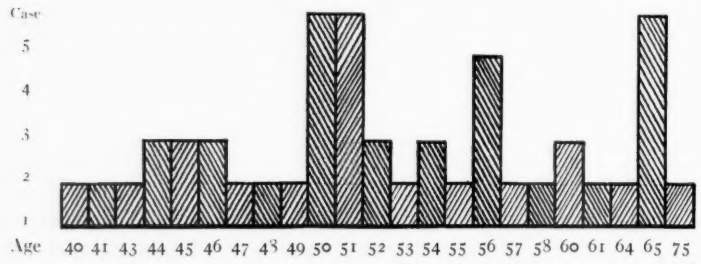

Fig. 1. The age incidence of osteo-arthritis of the spine.

cific antiserum and antigen. In the chronic arthritis group he was able to isolate the organism in 11 cases of chronic arthritis, 2 cases of vague rheumatic pains, and 1 case of acute myositis.

An attempt was made in this study to isolate the organism described by Small from cases of spinal arthritis of the chronic group with hypertrophic changes in the vertebræ. Throat cultures in 44 cases showing the lesion were made by inoculating swabs taken from the tonsillar pillars, tonsils, and abscessed teeth on blood agar plates of hydrogen-ion concentration 7.6 according to the description of the cultural methods used by Small. Streptococci which presented macroscopic features resembling those of the cardio-arthritidis group were subcultured in beef infusion broth of hydrogen-ion concentration 7.6. The indifferent streptococci thus isolated were tested for agglutination phenomena, the specific antiserum of the streptococcus cardio-arthritidis in a 1:2000 dilution being used, a dilution according to Small not likely to pick up associated serologic strains in a group reaction. Control agglutinations were made in which a bacterial suspension of the streptococcus cardio-arthritidis and its specific antiserum were used. Non-hæmolytic streptococci were isolated from the throats of 25 osteo-arthritis cases. Agglutination with the streptococcus cardio-arthritidis antiserum occurred in no instance, indicating that the non-hæmolytic streptococci thus isolated did not belong to the group described by Small as occurring in selected cases of chronic arthritis.

The pathology of the condition has been well studied. Most authors describe the process as beginning in the intervertebral discs with progressive absorption and calcification extending to the bone, resulting in apposition and fusion of the vertebræ by bony deposits. With this there occur proliferative changes at the edges of the bodies of the vertebræ resulting in lipping and exostosis formation. The latter may be so marked as to cause locking of the vertebræ. This disease, however, is not limited to the bodies and intervertebral discs but extends to the lateral and articular processes causing narrowing of the intervertebral foramina with pressure on the nerves and ankylosis of the small intervertebral joints. In the thoracic region ankylosis between the vertebræ and ribs may occur. Involvement of the spinal ligaments also takes place. In the majority of cases these pathological changes are more marked on one side of the spinal column and tend to spread along the involved side, with the result that the symptoms are more severe on that side. The process usually begins in the lumbar region and tends to spread upward involving the entire spine. As a rule, other joints, especially those of the fingers, are attacked. Cases vary in degree of involvement and rate of progression.

Clinically, as well as pathologically, hypertrophic osteo-arthritis of the spine has been mentioned as a cause of pressure on the spinal nerve roots emerging from the spinal column. This pressure causes nerve pain and tenderness which in the intercostal nerves supplying the abdominal wall may simulate visceral disease. It is the opinion of most writers that the bone spurs are not responsible factors in producing the pressure, but rather a soft tissue exudate. Nathan, in a study of the neurological conditions associated with spondylitis states that, clinically, the neural symptoms are those of moderate radicular or spinal irritation or compression produced by a periradicular exudate thrown out by the inflamed periosteum of the spinal canal and the intervertebral foramina. He found experimentally that the vertebral changes which are induced by inoculating dogs with streptococci are similar to those in the skeleton elsewhere. The changes are endosteal and subperiosteal inflammation. In the spine this exudate involves the epidural space and vertebral notches; it is of such a nature that it must, perforce, cause root or spinal irritation or compression. Carnett states that intercostal neuralgia after the age of 35 or 40 years is most commonly due to arthritis of

the spine. Gunther calls attention to the radicular syndrome in hypertrophic osteo-arthritis of the spine and in a study of 30 cases demonstrated bilateral radicular sensory disturbances which correspond to the vertebræ involved.

In this series the 44 patients showing the lesion were carefully studied to determine the neural involvement. The method of examination for detection of this condition is that described by Carnett, consisting of the A and B test for abdominal nerve tenderness, pressure over nerve trunks and terminal distribution, and skin fat pinch. Patients who showed positive signs by these methods were then examined by the methods employed by Gunther in his study; namely, sensory examination with a cotton tuft, pin point, heat and cold, and pinching, in an attempt to determine the particular nerve trunks affected. Of the 80 patients examined, 25, 31.3 per cent, showed nerve root involvement; 17, 21.25 per cent, showed peripheral nerve tenderness with evidence from cutaneous tests that nerve roots were involved. None of these, however, had a subjective complaint which could be attributed to the nerve root involvement. Of these 17 cases, 10, 58.8 per cent, had osteo-arthritis and 7, 4 per cent, did not. Eight patients, 10 per cent, showed nerve root pressure signs and did have subjective complaints arising from this condition. Of these 8, 4 had extensive spinal osteo-arthritis while 4 had no clinical or X-ray evidence of arthritis. This would indicate that osteo-arthritis may in some instances produce nerve pressure and in others may not. The accessory factor is not accounted for, but from the fact that the 8 who showed symptoms had recently suffered or were suffering at the time from a systemic infection, the majority from influenza, the inference may be made that a latent periradicular inflammatory process was lighted up.

The 8 cases showed characteristic features. Pain, paræsthesia, and hyperæsthesia were prominent symptoms. The pain in each instance was dull, aching, always intensified by motion, and was frequently worse at night. Limitation of spinal movement, most evident in flexion and lateral bending, was noted in all cases. Dejerine's sign, considered pathognomonic of radiculitis, was present in all. Sensory alterations were distributed according to the spinal root topography. In each, a recent or associated systemic infection, chiefly upper respiratory, was noted. In none of the 8 was the blood Wassermann reaction positive. Three showed excessive lumbar lordosis, 2, a slight scoliosis. Of the 17 showing nerve tenderness without complaint 6 had scoliosis, 3 excessive

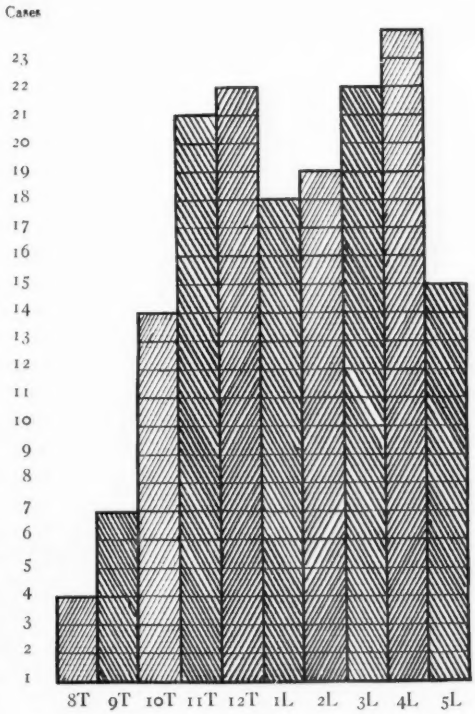

Fig. 2. Vertebræ showing frequency of involvement.

lordosis, and 5 excessive kyphosis. The incidence of backache was determined for the reason that low back pain has been attributed by some to osteo-arthritis of the spine. In this series, 19, 23.7 per cent, complained of backache; 13, 16.2 per cent, had backache and osteo-arthritis; while 31, 38.7 per cent, had no back complaint but osteo-arthritis was present. Six, 7.5 per cent, had backache without osteo-arthritis being found.

Considerable attention has been given to the simulation of visceral disease by radicular syndrome. Chute, in 1905, reported 5 cases of osteo-arthritis of the spine in which the referred pains simulated lesion of the kidney, prostate, or seminal vesicles. In 1917, Blaine called attention to the simulation of symptoms of renal or ureteral disease in cases showing only spondylitis. In a series of 87 cases of spondylitis, Vanderhoff found 40 who complained of abdominal pain. In 17 of the 40 the presence of visceral disease could be demonstrated, and the part played by spondylitis was either questionable or negligible. In 23 cases careful and complete studies excluded visceral disease as a cause of the patients' complaints. In

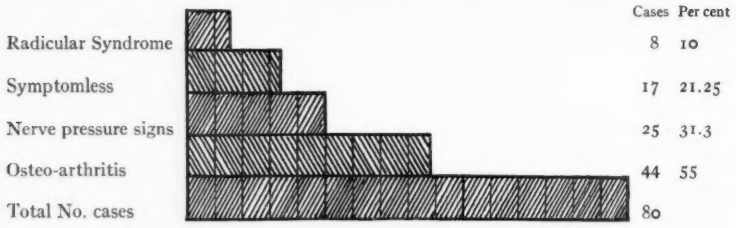

Fig. 3. The relative frequency of osteo-arthritis. Peripheral nerve tenderness and the radicular syndrome.

1923, Sloan called attention to the frequency of confusion in diagnosis of these cases stating that "the prevalence of spinal arthritis, its frequent association with abdominal pains, and the many mistakes in diagnosis which have been observed have been truly astonishing." More recently, Gunther has given a complete description of the radicular syndrome in hypertrophic arthritis in which he describes the characteristic symptoms arising from involvement of the various spinal nerves. Woolsey has emphasized the necessity of recognition of the radicular syndrome in the presence of abdominal symptoms, citing a case of spondylitis simulating a non-existent lesion. Parker and Adson report 8 cases of compression of the cord or its roots by hypertrophic osteo-arthritis in which the signs and symptoms were similar to those of extramedullary tumor of the spinal cord. Dickson and O'Neal report 3 cases of osteo-arthritis of the spine complicating disease of the abdominal viscera. Carnett has repeatedly called attention to mistakes in diagnosis resulting from this syndrome. Five, 6.25 per cent, in this series simulated visceral disease. Four of the 8 showing the radicular syndrome had been operated upon without relief; 2 of these were osteo-arthritides with nerve root involvement and 2 were typical intercostal neuralgias as described by Carnett. The case histories of the 5 simulating visceral disease are cited.

Case 1. Mrs. R. B. K., aged 51 years, housewife, was admitted to the hospital August, 1928, complaining of pain in the right upper abdomen. The onset was 7 years earlier and was attributed to striking the chest. For the past 4 years she had been frequently nauseated. Itching and tingling sensation occurred on the right side of the abdomen and chest. The distress was aggravated by jarring, sneezing, and coughing. There was constipation associated with gas formation. Three weeks before admission she suffered a mild influenza. Past illnesses were malaria, incipient tuberculosis in 1901, and influenza in 1928. She had been married 15 years; no pregnancies. She was told by two physicians that she had gall-bladder disease and operation had been recommended.

Essential findings on examination were tenderness of the right upper abdomen, chiefly under the right costal margin, and marked limitation of movement of the dorsolumbar spine. The X-ray examination revealed chronic fibroid phthisis but no evidence of pathology in the gastro-intestinal tract, moderately advanced osteo-arthritis of the ninth, tenth, and eleventh thoracic vertebræ; the kidneys were normal in size and position; gall bladder by the Graham-Cole method was apparently normal.

Laboratory reports showed the urine negative; leucocyte count 4,000; blood Wassermann negative; Van den Bergh .4 units; bile removed by Lyon's non-surgical drainage was normal and contained no calcium bilirubin crystals; blood chemistry normal.

Attention directed to the spine disclosed that the seventh, eighth, and ninth thoracic intervertebral spaces and intercostal nerve trunks on the right side were markedly tender to pressure. Movement of the spine was limited in the dorsolumbar region. The full movement caused pain in the back and abdomen. Hyperæsthesia of the skin supplied by the seventh, eighth, and ninth intercostal nerves on the right side was definite. Injections of novocain into the paravertebral spaces between the seventh and eighth, eighth and ninth, and ninth and tenth vertebræ on the right resulted in a loss of hyperæsthesia corresponding to the area of tenderness and hyperæsthesia previously determined on examination. During the effect of the nerve-block pain was absent.

A diagnosis of radiculitis simulating gall-bladder disease was made. Spinal fixation and bed rest gave relief. The resumption of full activity caused a recurrence of the complaint. The later appearance of associated pain in the extremities convinced the patient that her abdominal distress was not due to gall-bladder disease.

Case 2. H. M., aged 50 years, laborer, was referred January 15, 1929, for operation for subacute appendicitis. He had had a severe attack of influenza 3 weeks before admittance to the hospital and right lower abdominal pain followed. There had been no nausea or vomiting. Pain was aggravated by jarring, sneezing, and coughing. He also complained of some pain in the right chest and below the left costal margin. For many years he had suffered with stomach trouble, chiefly in the spring and fall, which consisted of pain in the epigastrium about an hour after meals. At these times vomiting occurred. There had recently been an undetermined loss of weight.

The essential findings were: normal temperature, and tenderness in the right lower quadrant, which was severe when the muscles of the abdomen were held tense. The intercostal nerve trunks in the dorsolumbar region were tender while the iliohypogastric and ilio-inguinal nerve trunks were markedly tender.

The laboratory reported the urine negative, the leucocyte count 5,000, and the blood Wassermann negative. The X-ray plates of the gastro-intestinal tract suggested a probable tumor of the pylorus while the X-ray examination of

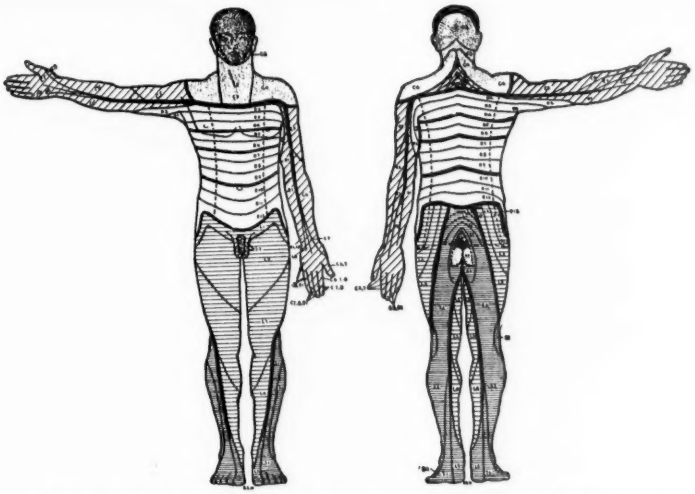

Fig. 4. The radicular sensory innervation. (From Mayer, J. Am. M. Ass., 1918.)

the spine revealed an extensive osteo-arthritis of the lower thoracic and all the lumbar vertebræ.

Examination of the spine showed an excessive lumbar lordosis. Motion in the dorsolumbar region was limited. The right paravertebral interspaces between the tenth and twelfth vertebræ were quite tender. Hyperæsthesia of the skin of the abdomen supplied by the tenth, eleventh, and twelfth right intercostal nerves was definite. Paravertebral injection of novocain blocking these nerves resulted in a loss of hyperæsthesia previously determined.

A diagnosis of radiculitis simulating appendicitis was made. On account of the previous history of stomach disorder, loss of weight, and the X-ray findings, an exploratory laparotomy was performed. The stomach was normal, the appendix was atrophic, showed no signs of acute pathology, and was not removed.

On discharge the patient was free of pain, probably from enforced bed rest. Nerve trunk tenderness and hyperæsthesia, however, persisted.

Case 3. T. T. M., aged 57 years, conductor, was admitted to the hospital February 20, 1929, complaining of pains throughout the abdomen, aggravated by jarring and by acute infections such as colds. Onset of illness was 10 years ago with severe pain and numbness in the left shoulder. Later, pain occurred in both hips and extended into the legs. Thoracic pain was present in the back and extended about the abdomen. The condition had been practically continuous since onset, except for short periods of remission. He complained a great deal of gaseous eructations but no vomiting.

He had had measles and diphtheria in childhood; typhoid fever and dysentery in 1898; in 1923 had fallen from a height striking on buttocks; appendectomy had been performed in 1924 without relief.

On examination no spinal deformity was found. The flexion, extension, and lateral bending of the spine was limited and painful. Abdominal tenderness in both lower quadrants was present. The right lower six intercostal nerve trunks supplying the abdominal wall were markedly tender, as best demonstrated when the muscles were tense. Cutaneous hyperæsthesia corresponding to the area supplied by the eighth, ninth, and tenth right thoracic nerves was readily made out. The X-ray plates of the spine showed an advanced osteo-arthritis of the eighth, ninth, and tenth thoracic and fourth and fifth lumbar vertebræ.

Spinal fixation gave temporary relief.

Case 4. C. S., aged 56 years, conductor, was admitted to the hospital February 10, 1929. He complained of pain in the right lower abdominal quadrant. He had had a mild attack of influenza one month before. There was no gastric disturbance and the bowels were regular. The temperature was 97.6 degrees. Examination elicited tenderness but no rigidity in the right lower abdominal quadrant. Tenderness was greatly accentuated when the abdominal muscles were tense. The right lower intercostal nerve trunks showed a tenderness from the spine laterally. The intercostohumeral, iliohypogastric and ilio-inguinal nerve trunks were exquisitely tender.

The laboratory reported the urine negative, the leucocyte count 5,400, and the blood Wassermann negative.

Cutaneous tests outlined an area of hyperæsthesia supplied by the ninth to the twelfth right intercostal nerves. Paravertebral block of these nerves resulted in loss of hyperæsthesia over this area. The X-ray examination of the spine revealed osteo-arthritis of the third lumbar vertebra but none was evident in the lower thoracic region.

A diagnosis of intercostal neuralgia simulating appendicitis was made. After a few days' rest in bed, the pain disappeared. Later examination showed a persistence of the area of hyperæsthesia.

Case 5. Mrs. F. A. P., aged 49 years, housewife, was admitted to the hospital August 1, 1928. She stated that for the past 20 years she had had sharp pains across the abdomen. The skin over the back, chest, and abdomen was always sensitive. Coughing and jarring aggravated the condition. The abdominal pain was chiefly in the lower left abdomen and radiated to the bladder region. She had recently had an acute upper respiratory tract infection.

Past illnesses consisted of a nervous breakdown in 1910 and severe influenza in 1918. Examination showed general abdominal tenderness, chiefly over the left side. There was no rigidity. With the muscles made voluntarily tense,

tenderness was exquisite. The supra-orbital, intercosto-humeral, and all intercostal nerve trunks were markedly tender. Excessive lumbar lordosis was present.

The temperature was 98 degrees; the leucocyte count 3,400; the urine negative; and the blood Wassermann negative. The X-ray examination of the gastro-intestinal tract showed no evidence of pathology. Cystoscopic examination revealed no pathology in the bladder, ureters, or kidneys. The spine showed no evidence of osteo-arthritis.

Hyperæsthesia to touch, cold, and heat was present over the lower abdomen to the left supplied by the lower intercostal nerves.

A diagnosis of intercostal neuralgia simulating an upper genito-urinary tract disorder was made. Bed rest and correction of the lordosis gave temporary relief. All symptoms recurred in a few weeks.

SUMMARY

Eighty unselected patients over 40 years of age were studied to determine the incidence of osteo-arthritis of the spine and the frequency of an associated radicular syndrome. Of these, 44 per cent showed evidence of hypertrophic osteo-arthritis. The average age of the patients was 55.6 years. The dorsolumbar region was the most often involved. Throat cultures from the 44 showing osteo-arthritis did not yield the streptococcus cardio-arthritidis in any instance. Focal infection was present in 56 per cent of all cases and in 68 per cent of cases showing osteo-arthritis. Twenty-five, 31 per cent, showed by neurological examination evidence of pressure on the spinal nerve roots. In seventeen, 21 per cent, no symptoms were found attributable to the arthritis. Eight, 10 per cent, had the radicular syndrome in which the complaint was entirely due to this condition. Four of the eight had osteo-arthritis, whereas, 4 had none visible to the X-ray. Of the 8 with the radicular syndrome, 5 had been operated upon without relief. In 5 the radicular syndrome simulated visceral disease.

CONCLUSIONS

1. Hypertrophic osteo-arthritis of the spine is a common affection in individuals beyond the fourth decade.

2. The majority of cases are silent showing no symptoms referable to the involvement of spinal nerve roots.

3. A small percentage have the radicular syndrome which may simulate visceral disease.

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EDITORIALS

SURGERY, GYNECOLOGY AND OBSTETRICS

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NOVEMBER, 1930

LIVER ATROPHY

LIVER atrophy is a purely descriptive term indicative of no specific pathological process, used loosely to denote the end-result of various inflammatory conditions of the liver, such as acute and subacute yellow atrophy, and cirrhosis. These lesions differ only in the duration, intensity, and extent of the inflammation. For the sake of clarity, they might better be termed "acute," "subacute," and "chronic" hepatitis. To regard the acute and subacute forms as way-stations on the road to the chronic type or cirrhosis would lead to a better understanding of their relationship.

The known causes are manifold. They comprise such substances as chloroform, carbon tetrachloride, tetrachlorethane, tribromethylalcohol, phosphorus, arsenic in its various forms, the toxins of eclampsia and exophthalmic goiter, parasites such as the treponema pallidum, and bacteria and their toxins and so forth. More than one cause may be responsible in any particular instance.

The intensity and duration of the exposure to the cause determines the variety of lesion resulting. A brief exposure to a virulent poison like chloroform produces an acute hepatitis, which is characterized by a swollen, tender liver, secondary to the cloudy swelling of its component hepatic cells. This stage is soon followed by a reduction in the size of the liver due to collapse of the necrotic liver cells. If death ensues, no fibrosis or regeneration is seen. Should recovery occur, the débris is carried away by the phagocytic endothelial cells and regeneration of normal liver tissue takes place in the as yet undamaged connective tissue framework of the liver.

A less severe, though more prolonged, exposure, in this instance months instead of weeks, would produce the subacute type. With the lesion of such duration there is marked connective tissue proliferation which restricts the regeneration within a heavy fibrous tissue framework, producing the so-called "nodular adenomatous hypertrophy," characteristic of subacute hepatitis. When the process is further prolonged, a true chronic hepatitis or cirrhosis appears. That an intercurrent infection arising either in the biliary tract or portal blood stream, augments the degree of fibrosis has been noted by Whipple and Sperry, Schultz, Hall and Baker, and Moise and Smith.

Fortunately, certain observations on diet have proved of great help in protection against these lesions. Opie and Alford showed that while a high fat diet increased the susceptibility of livers of dogs to necrosis following the administration of chloroform, a carbohydrate diet had a distinctly protective action. Moise and Smith, investigating the toxicity of chloroform and the degree of necrosis on

various types of diets, found chloroform most toxic on a fat diet and relatively less so on a mixed diet, a carbohydrate diet, and a protein diet in the order named. Whipple and Davis produced a central necrosis in the livers of dogs, giving chloroform either as an anæsthetic or subcutaneously and found that regeneration occurred most rapidly on a high carbohydrate diet or mixed diet. Mann and Magath have shown that glucose is essential for the optimum maintenance of dehepatectomized dogs.

Bollman has observed that in dogs with a biliary cirrhosis produced by obstruction of the common bile duct, life may be prolonged up to 10 months if they are fed on a diet of syrup, bread, and milk, but that a diet of meat is rapidly fatal, death occurring within a week or 10 days. He also noted that ascites appeared within a few hours in these jaundiced animals after feeding them meat or meat extract and that it disappeared rapidly with the substitution of large amounts of carbohydrates. Somewhat later he found that in dogs with experimental portal cirrhosis, produced by feeding carbon tetrachloride or tetrachlorethane, a diet consisting of milk and corn syrup afforded protection to the liver cells and aided regeneration. The dogs fed on a high protein diet chiefly of meat, showed symptoms of profound toxæmia, more marked destruction of liver cells, and very little capacity for regeneration.

In the atrophies of the liver, recognition of their true nature is of primary importance. It is well known that these patients are exceedingly poor surgical risks, that they are more susceptible to toxic agents, and that their wounds heal slowly. These facts have demonstrated the lack of hepatic reserve far better than the laboratory. Obviously the surgeon should be guarded in accepting such a patient for operation.

Luetic hepatitis should always be excluded before the administration of arsenicals. True biliary colic may be very difficult to distinguish from the severe distress of hepatic pain. In the acute and subacute forms of hepatitis, the jaundice is often described as being of an orange rather than greenish hue. The stools are usually pigmented and the urine may contain leucin and tyrosin crystals, indicative of liver necrosis rather than insufficiency. Umber has described a characteristic "fetor hepaticus" or "amine" breath. The blood urea rises only as a terminal feature presumably due to a nephrosis caused by the retained bile acids. True evidence of insufficiency of the known liver functions is almost impossible of laboratory proof.

These data have proved helpful in the consideration of each individual case of jaundice as it confronts and perplexes us. Atrophy of the liver persists as a refractory surgical problem since in arriving at a diagnosis one must differentiate stone, neoplasm, stricture, and infection of the biliary tree. The bugbear of gastro-intestinal hæmorrhage still remains in spite of the Talma-Morrison omentopexy and Walter's adaptation of their procedure to the gastrohepatic omentum. F. C. FISHBACK.

CARCINOMA OF THE COLON

AT a recent hospital clinical-pathological staff conference two cases were considered which emphasize in no uncertain manner the need for constant vigilance in the diagnosis of carcinoma of the colon.

The two patients were between fifty and sixty years of age and both gave, among other more striking but less characteristic symptoms, the story of a decided *change in their habits of bowel movement during the previous few months*. One of these patients was admitted with acute intestinal obstruction for

which an ileostomy was immediately performed, no diagnosis being made. No barium X-ray study was subsequently carried out. Six weeks later the ileostomy was closed with resulting obstruction, peritonitis, and death. Autopsy revealed an early annular carcinoma of the colon at the hepatic flexure. No metastases were found either in the regional lymph nodes or in the liver.

In the second patient barium was given by mouth and the entire gastro-intestinal tract was pronounced essentially normal. At a laparotomy the gall bladder, which was moderately thickened and contained several stones, was drained and a right ovarian cyst was removed. The pyloric opening was noted to be small but the stomach was not much dilated. The patient vomited repeatedly and a gastro-enterostomy was made at a second operation. The vomiting persisted and one week later an ileostomy was performed and the patient succumbed. At autopsy a very early, partially-obstructing carcinoma of the colon was found at the splenic flexure. There were no metastases.

Several years ago I heard Doctor Daniel F. Jones, of Boston, make a remark to the effect that each year, in his opinion, two or three patients with carcinoma of the colon were turned away from every large out-patient department with the advice that they should regulate their bowels. It is evident, however, that the younger medical men, who see the patients in many of these out-patient clinics, are not alone in their failure adequately to heed the all-important statement of the patient that his "*bowels do not move as they used to.*"

Operating surgeons should, personally, (1) take a careful history, (2) observe and palpate the abdomen, (3) make a rectal examination, (4) use the proctoscope and sigmoidoscope, (5) utilize the evidence of the barium enema, but discount the results when negative or inconclusive, and (6) at laparotomy explore with care every inch of the colon.

Particularly in patients over thirty-five years of age, the fact of a *change in the habits of the colon* should make the surgeon so suspicious of cancer in this organ that he will not allow his attention to be diverted from the large bowel, either by incidental pathology or by lack of evidence of marked obstruction, until he has proved beyond all doubt that a lesion is not present there.

CLARENCE E. BIRD

MASTER SURGEONS OF AMERICA

JOHN JONES

THE finest traditions of organized science spring from the impulses which animated the early masters. The life of Dr. Jones is intimately associated with the earliest and most inspiring traditions of the science of surgery in America.

He came of sturdy Welsh lineage. His grandfather, Dr. Edward Jones, emigrated from Wales in the ship "Welcome" with William Penn and his colony. He married the daughter of Thomas Wynne, speaker of the Penn Assembly. His son, Dr. Evan Jones, married Mary Stephenson, also of the Penn Colony, and settled in the town of Jamaica, Long Island, where the subject of this sketch was born in 1729. He was the eldest of four sons and his academic schooling was conducted by his father and mother in their home and in a private school in New York City.

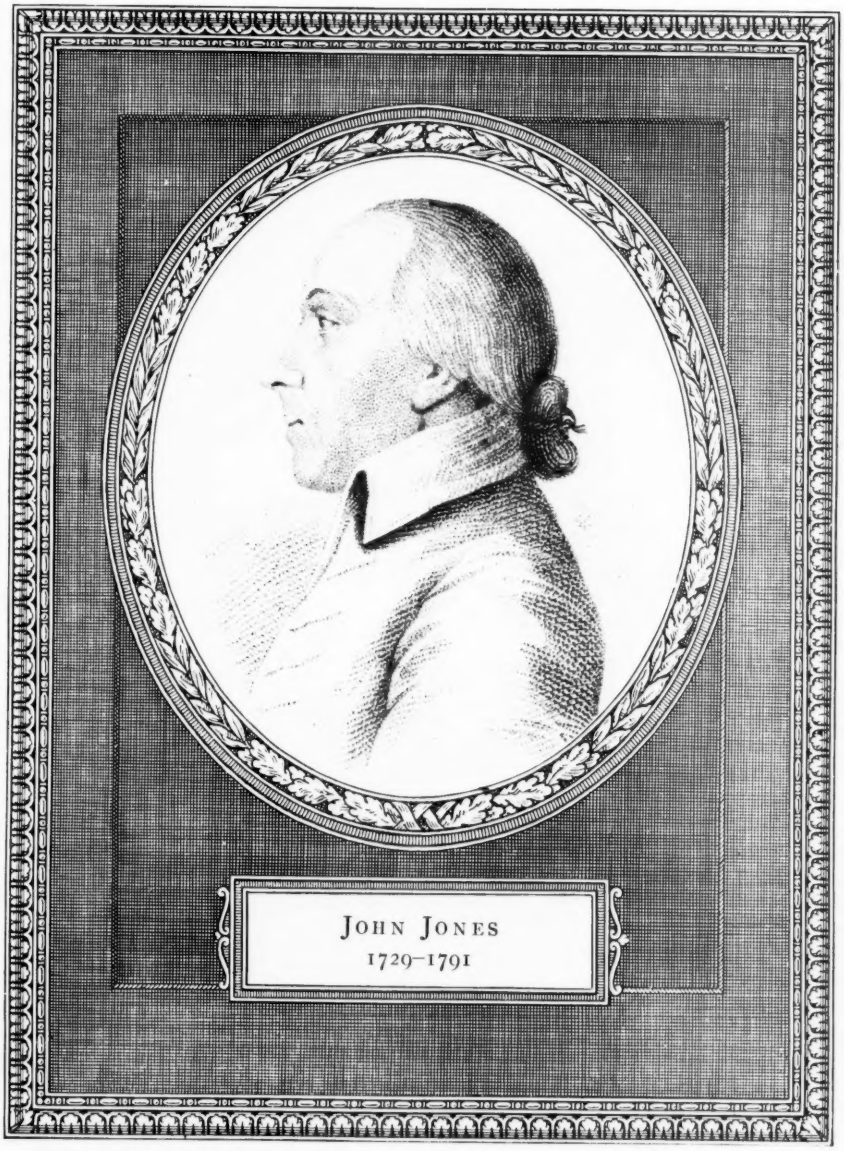
It was the wish of John's father that he should study medicine and at the age of eighteen he was placed under the tutorship of Dr. Thomas Cadwallader, one of Philadelphia's most distinguished physicians. He was there brought in intimate relationship with the socially elect of Philadelphia, who were the friends of his own family and whose influence was in later years to form a most important background for his professional life in that city.

Jones was a conscientious and hard working student, ambitious to excel in all the opportunities offered by his illustrious preceptor.

America at that time had no medical college nor any hospital with an organized clinic where a student could be trained in course; and the facilities for clinical study were limited to the private patients of his preceptor.

After completing his training under Dr. Cadwallader, Jones went abroad, carrying letters from his preceptor to the master anatomists and surgeons of Britain and France. In London he became the pupil and eventually the intimate friend of Percival Pott, whose surgical clinic at St. Bartholomew's was justly celebrated. He also took the lecture course of William Hunter in anatomy and became a friend of John Hunter who was completing his course in medicine.

After finishing his courses of study in London young Jones went to France. He had acquired a reading and colloquial knowledge of the French language and first became a student at the University of Rheims where he received his degree



JOHN JONES
1729–1791

of Doctor of Medicine in 1751. From Rheims he returned to Paris, where he remained until April, 1752, with Professor Petit in his work in anatomy and in the surgical clinics at Hôtel Dieu with Professors Le Cat and Le Dran. From Le Dran, who was one of the first urological surgeons of his time, he learned to do lithotomies with skill and facility. From Paris he went to the University of Leyden and thence to London to be again with Pott and the Hunters, ending his tour of foreign study with the elder Munro in Edinburgh.

In 1753, Dr. Jones returned to New York to open an office and put in practice the accummulated knowledge gained from study with the teachers abroad.

Dr. James Mease, his biographer, commenting on the warm friends Jones had made among the master surgeons of Britain and France quotes some of the ideas which animated this brilliant young student, who had formulated the following course for the scientific surgeon:

"Besides a competent acquaintance with the learned languages, which are to lay the foundation of every other acquisition, he must possess an accurate knowledge of the structure of the human body, acquired not only by attending anatomical lectures, but by frequent dissections of dead bodies with his own hands. . . . There must be a happiness as well as art, to complete the character of the great surgeon. He ought to have firm steady hands and be able to use both alike; a strong clear sight, and above all a mind calm and intrepid, yet humane and compassionate, avoiding every appearance of terror and cruelty to his patients amid the most severe operations. . . . Whoever has acquired just and general ideas of the nature of a disease will seldom be at a loss how to apply them on particular occasions; and to him who wants those ideas, no rules or directions will be of much consequence."

In 1758, during the war between France and the British Colonies in America, when the invasion of New York was threatened at the Battle of Lake George, Dr. Jones enlisted as a military surgeon. The French general in chief command, General Baron D'Escaux was dangerously wounded and was taken prisoner by the British. Having learned of Dr. Jones' skill and that he had been a student of Le Dran, the French General sent for him to treat his wounds. The American surgeon continued to care for Baron D'Escaux after he was transferred to New York.

At the end of the campaign Dr. Jones returned to his surgical practice. His fame had now became widespread in the Colonies and his services were soon in demand everywhere. His skill in doing the operation of lithotomy, which in a very brief time he had brought from a procedure of great risk and high mortality to one of safety, brought him a well merited reputation. Moreover, Percival Pott had proved a loyal friend to his capable pupil and was unfailing in commending Dr. Jones to patients in America who sought his counsel. This cordial attitude on the part of Mr. Pott and the fine training under Professor Le Dran in urologic

surgery, which hitherto had been in bad repute in America, gave impetus to Jones' reputation as one of the most skilful and outstanding surgeons of his time. He performed the first lithotomy done in New York. Dr. Mease wrote of him: "He had acquired a facility in operating to which few surgeons had arrived. I have seldom known him longer than three minutes in a lithotomy and he has sometimes finished the whole in one minute and a half."

At the organization of the medical school in the College of New York (now Columbia University) Dr. Jones was appointed professor of surgery. He had had a careful training in obstetrics and up to this time obstetrics and surgery were taught in the same lecture course by the same teacher. He came back from Europe with the conviction that surgery was a distinct and separate branch of practice and should be taught and practiced as such. He not only was the first professor of surgery in America but from that time on was accorded the title of "Father of American Surgery."

Since his boyhood he had suffered greatly from asthma. His health from this malady became so impaired he finally determined to go to London to be with his old friends there with the hope that the fogs of London would afford him relief. Strange as it may be, he did grow better and stronger in this environment, and attributed his improvement in health to this change in climate. He again attended the clinics of Mr. Pott and the lectures on anatomy by Dr. Hunter. The personal courtesies and social hospitalities extended to him by them and notably by Mr. Pott, were a life-long inspiration to him. While in London he succeeded in raising the funds needed to complete New York's first hospital.

The threatened outbreak of the War of the American Revolution cut short his stay in England and he returned to New York, enlisted for the war, and served with Warren, Bard, and Morgan in the organization of the medical department of the Colonial Forces. In 1775 his chief and principal work on surgery was published. Its title was *The Plain, Concise, Practical Remarks on the Treatment of Wounds and Fractures*. At the beginning of the war there was a great dearth in the Colonies of young surgeons who were capable of treating gunshot wounds and fractures. This book so replete with knowledge Jones had acquired in the clinics of Le Dran and Pott proved an invaluable handbook for the young military surgeons in this war, and for many years afterward to the surgeon in civil practice.

When the British forces occupied the city of New York its three or four leading surgeons, Jones among them, found it necessary to leave; and inasmuch as he had previously been benefited by the climate of Philadelphia and had many friends there, he took up his residence and opened an office in that city in the summer of 1778. On the resignation of Dr. John Redman in 1780 from the Pennsylvania Hospital, Dr. Jones was unanimously elected to succeed him and continued to serve on its staff until his death eleven years later. When in 1787 the

Medical College of Philadelphia was organized, Dr. Redman was elected president and Dr. Jones vice president.

He became not only the physician of Benjamin Franklin but his intimate personal friend and was remembered by Dr. Franklin in his will. Dr. Jones has written a most interesting and detailed account of the last illness of his illustrious patient which his biographer incorporated in the narrative of his life. The intimacy and delightful fellowship which bound the great philosopher to his surgeon friend had its counterpart earlier in his life with Percival Pott and was to be greatly enriched by a notable friendship with President Washington, whose physician he had been for years and whom he attended for some indisposition the afternoon of the day Dr. Jones died.

Among the contributions to the surgical literature of the time in addition to the volume on the *Treatment of Wounds and Fractures*, were *Camp and Military Hospitals; The Diseases Incident to Armies, with the Method of Cure; Graduation Thesis at the University of Rheims*, 1751; *Account of the Last Illness of B. Franklin*, 1790; *A Case of Anthrax*, 1791.

He had trephined and opened the dura in a patient with delirium and symptoms of cerebral abscess eighty days after a head injury which terminated in recovery. This was one of the first operations on the brain in America and is reported in his work on the *Treatment of Wounds and Fractures*.

His notable executive ability in organizing the Department of Medical and Surgical Service at the beginning of the American Revolution has previously been mentioned. So active was he in the public affairs of his city and State that he was made a senator in the State of New York.

This cultivated gentleman of versatile accomplishment was an illustrious surgeon of international note, a loyal patriot, a splendid citizen, and a devoted friend of humanity. He was an honor to the profession he loved and the guild which his achievements distinguished.

The life and ideals of this noble-minded teacher and master should be an inspiration to all who have followed the course and development of the science of surgery in America.

ANDREW STEWART LOBINGIER.

THE SURGEON'S LIBRARY

OLD MASTERPIECES IN SURGERY

ALFRED BROWN, M.D., F.A.C.S., OMAHA

JAN VAN HEURNE

THE national or rather international reputation attained by van Foreest would be expected to stimulate Hollanders to take up medicine and practice it in their own country. Consequently, following Forestus by a few years another Hollander was to gain a great reputation. Jan van Heurne, more commonly known as Heurnius was born at Utrecht in 1543, twenty-one years later than Forestus. There being no University in Holland he began his studies at Louvain in 1561 as a pupil of Cornelius Gemma. Following his training there he began the usual wanderings of the young medical man of the time to the important universities of the continent. His first point was Paris. Here he studied under Ludovicus Duretius, the great student of Hippocrates, and obtained from him the interest in the physician of Cos which was to initiate his later activity in studying the works of the ancients. After Paris he went to Padua and came under the tutelage of Hieronymus Cappivaceus, Fabricius of Acquapendente, and Hieronymus Mercurialis. In 1571 he obtained his doctor's degree at Pavia. At this time the revolution led by William of Orange against King Philip was gaining headway and it appeared he might accomplish something at home. Accordingly he returned to Utrecht and began to practice. As he had joined the Protestant cause and embraced its religion he was *persona non grata* to the Spanish soldiery and had to put up with some indignities, but he refused to be driven out. At this time his interest in the ancient physicians, especially Hippocrates, stood him in good stead, for he apparently worked along this line when he was not busy with his practice and thus may have taken his mind off the troublous times his country was going through.

In 1575 the University was established at Leyden and 6 years later he was called to it as professor of medicine. He accepted and was able to practice there the clinical method of teaching that he had learned in his student days. He remained in Leyden the rest of his life, constantly associated with the University of which he later became Rector, serving six terms in that office. He died in 1601.

Heurnius sprang into prominence soon after his return to Holland and gained a high position due to his powers of diagnosis which soon brought him in contact with the ruling powers and gave him many prominent patients. One of these was the Count of Noortcarmes who was suffering from jaundice the cause of which could not be made out. Heurnius discovered that it was due to poison which was being given him by the Spaniards. The Count was Governor of Utrecht and so one of whom the Spaniards were anxious to be rid. He also took care of Count Egmont, the Governor of Flanders and Artois, who chose him as his physician even though Heurnius was a protestant and Egmont a catholic. Egmont's religious belief was not strong enough to make him countenance the tyranny that Philip II of Spain was trying to introduce into the Netherlands. We have, then, the picture of a clever and learned medical man, well thought of at court, closely connected with important people, and able to use this for a sinecure, but still working constantly at his science, for though he did not begin to publish until moderately late in life his publications were numerous and worth while.

In 1587 his first book appeared under the title "A New Science of the Practice of Medicine," *Praxis Medicinae nova ratio*, and from then on they appeared with but little time between. The year after his death, 1602, two volumes, one on diseases of the eye, ear, nose, teeth, and mouth and another on diseases of the chest were published posthumously but it is probable that the greater part of the labor of seeing them through the press was performed by Heurnius himself, though his son had to do with the actual publishing.

Though primarily an internist, Heurnius does not neglect diagnostic surgery and even goes so far as to describe the indications for some surgical procedures. For headache he advises phlebotomy, arteriotomy, and the actual cautery. The last he also advises together with scarification and local bleeding in hydrophobia, and his description of this disease is the most important part of the work on "Diseases of the different parts of the human head." It is exceedingly clear and shows an excellent knowledge of the subject in hand. Likewise in the portion of the book devoted to paralysis, Heurnius comes so near making important discoveries that one wonders how he happened to miss them, his observations are so complete and clearly expressed but his knowledge of anatomy and physiology was too incomplete. His discussion of atrophy in connection with paralysis is one which would have been of greater value had he applied it to the treatment of disability following fractures.

I. HEVRNII
VLTRAIECTINI
DE MORBIS
QVI
IN SINGVLIS PARTIBVS
HVMANI CAPITIS
INSIDERE CONSVEVERVNT.

Hîc artificiosâ methodo, & incredibili facilitate, morborum Ideæ, Cauſæ, & cuiuſque cauſæ morbificæ, partiſque ægræ Signa. Prognoſes, & Curatio Rationalis & Empirica graphicè depinguntur.

Cum Rerum & Locorum inſignium vtiliſſimo INDICE.

LVGDVNI BATAVORVM,
EX OFFICINA PLANTINIANA,
– Apud Franciſcum Raphelengium.
clo. Io. xciiii.

REVIEWS OF NEW BOOKS

CAMPBELL presents a valuable orthopedic text,[1] which should appeal to the student or practitioner because of its clear, easy style and its comprehensiveness. The arrangements of subjects are rather unique and most satisfactory: the main divisions being affections of joints, affections of bone, affections of soft tissues, affections of the nervous system, static deformities, and congenital anomalies. The increasing scope of orthopedic surgery is reflected in the well organized chapters on fractures, dislocations, and bone tumors. Selected useful operative procedures are presented with discussions of indications and technique. Chapters on ankylosis and arthroplasty command especial attention. Other outstanding chapters are those on examination of the patient, tuberculosis of joints, and anterior poliomyelitis. FREMONT A. CHANDLER.

THE second part of Volume I of *Chirurgie der Brustorgane*[2] by F. Sauerbruch deals with the surgical treatment of pulmonary tuberculosis, neoplasms of the lung, echinococcus and actinomycosis of the lungs, the surgical treatment of bronchial asthma, and pulmonary lues. The book also contains a very comprehensive bibliography covering the subject matter treated in volume I as well as the index. The general appearance of the second half of the first volume is similar to that of the first half and brings the chapters discussed up to date.

In discussing the work as a whole, for those who are not acquainted with the previous additions, it should be said that Sauerbruch's *Chirurgie der Brustorgane* is the outstanding work on surgery of the chest. It is the standard reference text emanating from the largest and best known chest surgery clinic in the world. It is excellently written and profusely illustrated with diagrams, X-ray pictures, actual photographs, drawings, and some of the most beautiful color plates that the reviewer has ever seen. Sauerbruch's *Chirurgie der Brustorgane* should be in every library, and will be found on the shelves of every surgeon or internist who is interested in thoracic conditions. RALPH BOERNE BETTMAN.

A MOST interesting book to own and read is Beckman's *Treatment in General Practice*,[3] it covers general medical treatment in an unusual manner. As the author states, it is in no sense his own attempt to be authoritative in this enormous field. On every subject and on every page there is prolonged quotation and reference. Thus, the book is a collection of medical opinions on every subject, with intelligent and interesting editorial comment. With rare exceptions the author's own opinions are not intruded. On controversial problems (and they are many) both sides are represented. As is to be expected, the surgeons are not adequately praised for their treatment of hyperthyroidism, but a surgeon is allowed to present the discussion of medical versus surgical treatment of peptic ulcer. As an illustration of the manner in which the book is done, take the portion on the treatment of peptic ulcer: First, Dr. Arthur Dean Bevan's discussion of the medical versus surgical treatment is quoted for 2 pages; Sippy treatment is quoted from Sippy for 3½ pages; Alvarez on the treatment of duodenal ulcer is quoted for 3 pages; Andresen on the treatment of gastric hæmorrhage for 4 pages; and Bastedo for 1. These quotations are consecutive and are interrupted by very brief editorial comment. Most of the other important medical problems, such as the treatment of lobar pneumonia or heart disease, are handled in this same way. Reference is made and authority quoted on a great number of special medical problems from anthrax to sea-sickness. Sections on diseases of the skin, genito-urinary tract, and nervous system, acute poisoning and obstetrics are included. On the whole this book represents very extensive reading, intelligent selection of material, and stimulating discussion. PAUL STARR.

THE fifteenth volume of Pauchet's *Practical Surgery*[4] includes monographs on free scalp grafts for the replacement of eyebrows; the radical treatment of frontal sinusitis, in which the frontonasal canal is enlarged by means of a small curette and the tampon passes into the nasal cavity. An interesting case of cutaneous sarcoma of the arm is given in detail; the tumor was removed *in toto* and a pedicle flap from the chest used to cover the defect. A diaphragmatic hernia of the stomach in a boy of 13 is beautifully illustrated, the interesting item being that the X-ray plates did not reveal the abnormality.

Subserous cholecystectomy is well described; the French school is swinging more and more toward cholecystotomy in order to treat the concomitant hepatitis. Gastric, duodenal, and jejunal ulcers are described in detail, most of them representing late relapses or complications. Lipectomy of the abdominal wall with esthetic transplantation of the umbilicus is well described by Mornard. Of less value are monographs on extirpation of the seminal vesicles and on testicular grafts, the latter based on Voronoff's work. The volume contains two hundred superb illustrations by that sterling artist Dupret. Pauchet's volumes should be of especial value to the beginner who is still orienting himself.

GEORGE DE TARNOWSKY.

[1] A TEXT BOOK ON ORTHOPEDIC SURGERY. By Willis C. Campbell, M.D., F.A.C.S. Philadelphia and London: W. B. Saunders Company 1930.

[2] DIE CHIRURGIE DER BRUSTORGANE. By Ferdinand Sauerbruch. 3d ed. vol. i, part 2. Berlin: Julius Springer, 1930.

[3] TREATMENT IN GENERAL PRACTICE. By Harry Beckman, M.D. Philadelphia and London: W. B. Saunders Company, 1930.

[4] LA PRATIQUE CHIRURGICALE ILLUSTRÉE. By Victor Pauchet. Vol. xv. Paris: Gaston Doin & Co., 1930.

IN an excellent little volume Pascalis[1] recounts his personal experiences with various surgical affections. Especially valuable are his comments on tendon repair, Pott's fracture, Buerger's disease, and penetrating wounds of the abdomen. The treatment of ascites which has given him the best results consists in tapping followed by the introduction of six liters of sterile hot water. In Pascalis's experience, over 60 per cent of all cases of cancer of the sigmoid and rectum are diagnosed too late for radical extirpation. Wherever possible he favors mobilization of the descending colon and sigmoid, resection of the cancer area, and suturing of the proximal sigmoid to the sphincter (if not involved) or to the levator ani. In prostatectomies he condemns packing the vesical pouch as being painful, and as leading to urinary retention, infection, and secondary hæmorrhage. Freyer's irrigation with hot saline has, in Pascalis's hands, always checked the vesical hæmorrhage. In describing the treatment of retroversio-uteri, Doléris is given sole credit for the technique known in America as the Barrett operation.

GEORGE DE TARNOWSKY.

THE subject of the mechanism of the larynx has been approached from a purely biological standpoint by Dr. Negus[2] who has traced the development of the organ from its lowest form to the highly developed mechanism known as the human voice box. In the author's own words "much has been written about the larynx, its physiology, anatomy, and the diseases which attack it, and still this small organ performs its work shrouded in mystery. It cannot be said that anything detailed is known about its mechanism either in the animal kingdom or in man. It is generally known as the organ of voice but it must be observed that thousands of species which have a larynx never, or practically never, make use of voice."

Dr. Negus has traced the reasons for its existence and the steps of its evolution in response to demands made on it. We learn that the larynx first appeared as a mechanism guarding the lung fields and that throughout its evolution this protective measure seems to be its chief function even in the higher vertebrates. The vocal cords were originally muscular valves designed for respiratory purposes but later were used for the production of sound and ultimately for speech. To Dr. Negus, the human larynx demands attention purely because it is one rung in the evolutionary ladder. No mention is made of the various diseases which attack the larynx and the book is devoid of all clinical tables and statistics.

One need not know especially anatomy or medicine to understand this work. It is self-explanatory and the author has succeeded in unraveling many mysteries of the larynx and teaching us many new things. The text is of good paper and extremely well illustrated. This is a monumental work and one that will be referred to many times by laryngologists and teachers of voice. One cannot praise Dr. Negus too highly for his work.

JOHN F. DELPH.

ONLY a few years ago the first edition of Wright's excellent and worthwhile book on *Applied Physiology*[3] was reviewed. It has become a popular book among medical students and clinicians. The interest of the author in his work is manifested by the fact that only a year has elapsed since the publication of the previous edition. A number of sections have been altered, old matter being deleted and new data and facts introduced. A new section of sixteen pages on conditioned reflexes has been added which augments the value of the book. The book is useful not only in that it contains much clinical physiology, but assists a great deal in understanding and appreciation of symptoms.

A. C. IVY.

THE rich experience of Korányi[4] with a subject in which he has carried on pioneer, fundamental investigations is reflected in his book on diseases of the kidneys. The book had its origin in a series of clinical lectures which incorporated the results of studies by the writer and his associates during a period of 35 years. The present work has preserved the lecture form and includes a survey of much of the literature on the subject. No attempt has been made to provide a systematic presentation for use as a textbook of diseases of the kidney. The first five lectures are devoted to the biological and clinical foundation of functional pathology, diagnosis, and treatment. The remaining lectures include the following subjects: high blood pressure, nephrosclerosis, uræmia, the nephroses, acute glomerulonephritis, the kidney of pregnancy and of mercury poisoning, and the chronic nephritides. The final chapter contains an exceptionally well balanced review and summary; the points of divergence in the view-point of pathologist and clinician are described, and the principles of classification of kidney diseases are elucidated.

WALTER H. NADLER.

THE monograph by H. Morriston Davies on *Surgery of the Lung and Pleura*[5] is one of a system of books entitled *Regional Surgery*, edited by A. P. Bertwistle.

In perhaps no other branch of surgery is another textbook as welcome as in the field of thoracic

[1] CLINIQUE ET THÉRAPEUTIQUE CHIRURGICALES. By George Pascalis. Paris: Gaston Doin & Co., 1930.

[2] THE MECHANISM OF THE LARYNX. By V. E. Negus, M.S. (Lond.), F.R.C.S. (Eng.). With introduction by Sir Arthur Keith. St. Louis: The C. V. Mosby Company, 1929.

[3] APPLIED PHYSIOLOGY. By Samson Wright, M.D., M.R.C.P. 3d ed. New York and London: Oxford University Press, 1929.

[4] VORLESUNGEN UEBER FUNKTIONELLE PATHOLOGIE UND THERAPIE DER NIERENKRANKHEITEN. By Dr. Baron Alexander v. Korányi. Berlin: Julius Springer, 1929.

[5] SURGERY OF THE LUNG AND PLEURA. By H. Morriston Davies, M.A., M.D., M.Ch. (Cantab.), F.R.C.S. (Eng.). New York and London: Oxford University Press, 1930.

surgery. The monumental *Chirurgie der Brustorgane* of Sauerbruch in German and the two-volume *Thoracic Surgery* of Howard Lilienthal in English are the outstanding works. The reviewer knows of no effort, in recent years at least, to cover the field of chest surgery in a short text, which can be used for students or graduates whose time or inclination do not warrant an exhaustive study. In English many excellent monographs have appeared on certain phases of chest surgery but none on the subject as a whole. H. Morriston Davies' *Surgery of the Lung and Pleura* not only fills an empty space but fills it well. In about 300 pages he covers his subject in a clear, concise manner. The work is short but not superficial. The text is illustrated with many good X-ray reproductions and also some diagrams. The fact that the author is in reality a specialist in diseases of the chest and not a general surgeon, gives him a broad outlook over this field. This is reflected in the excellent paragraphs on diagnosis and therapeutic indications. The book contains all and more than the usual student or physician will want to know about chest surgery and has numerous references for those who want to delve deeper in the subject.

RALPH BOERNE BETTMAN.

THE fifth edition of Comyns Berkeley's *Gynæcology for Nurses and Gynæcological Nursing*[1] contains not only all that is reasonable to expect a nurse to know about gynecology but considerable practical information about obstetrics. More than half of this 400 page book is used to cover anatomy, physiology, pregnancy, parturition, and diseases of the reproductive tract, while the remainder is given over to gynecological nursing. Anatomy and physiology are treated in a clear, concise manner, and the clinical significance of anatomical or physiological variations are discussed in a practical fashion. The treatment of obstetrical emergencies are considered in such a way as to suggest operative interference by the nurse. The reviewer does not believe a nurse should attempt to remove an adherent placenta. Nor do we approve of the use of hot 120 degree F. intra-uterine antiseptic douches for uterine hæmorrhage, particularly postpartum.

Despite these minor criticisms this text is an excellent reference for nurses and supplements the lectures usually given so well that we have added it to our reference library for nurses.

SAM J. FOGELSON.

THE English edition of this monograph[2] is well worth reading. The author first reveals the essential methods in the treatment of eclampsia, and then gives the history of his prophylactic method, describing the surroundings and conditions under which he has been working, the history of the prophylactic methods, its results, his conception of the pathogenesis of eclampsia, and the methods of treatment. He then reports some instances of treatment which are of particular importance to practicing physicians. These instances give a closer idea of exactly what Stroganoff does.

There is very little to criticize in his presentation of the subject except that, in his endeaver to impress, he has repeated himself several times throughout the monograph. If he had not done this it would have shortened the work about twenty per cent.

The book is an excellent monograph for every physician who does obstetrics. E. L. CORNELL.

THE small manual[3] written by Richard M. Smith to aid mothers in the care of their infants during the first 2 years is well written and, what is equally important, is concise in the information given. Suggestions as to feeding are given with the reservation that a physician should direct the feeding and that such advice is given only for those who cannot avail themselves of the services of a physician familiar with infant feeding.

The instructions as to feeding will not meet with the absolute approval of all physicians as to the age at which certain foods are given, or the kind of sugar added to the milk mixture. This, however, is a question of the individual physician and of geography and it is realized that infants will thrive under a variety of methods.

The general advice about clothing, care of a sick child, and the outlining of a day's schedule of routine duties are excellent. GERARD N. KROST.

THE reference hand book by A. James Larkin[4] is intended for the guidance of the general practitioner in deciding when to refer cases for radium therapy. It covers quite completely the various pathological conditions in which radium is useful as a therapeutic agent. Each disease is discussed in a fixed outline form which includes a more or less brief paragraph under pathology, radium indication and contra-indication, application, reaction, and prognosis. This is followed by one or two case histories to illustrate the action of radium in the disease discussed. A short bibliography concludes each of these sections, and the appendix contains additional bibliographic references.

The book is obviously not intended for men who are experienced in the use of radium, nor is it an adequate manual of radium therapy. Those physicians, however, who confine their work to other fields but have occasional need for information regarding the value of radium therapy in a given case, will find that information concisely stated and easily available in this book.

[1] GYNECOLOGY FOR NURSES AND GYNÆCOLOGICAL NURSING. By Comyns Berkeley, M.A., M.D., M.Ch. (Cantab.), F.R.C.S. (Lond.), F.R.C.S. (Eng.). New York: G. P. Putnam's Sons, 1930.

[2] THE IMPROVED PROPHYLACTIC METHOD IN THE TREATMENT OF ECLAMPSIA. By Prof. W. Stroganoff. 3d ed. rev. Edinburgh: E. & S. Livingstone, 1930.

[3] THE BABY'S FIRST TWO YEARS. By Richard M. Smith, A. B., M.D., Sc.D. 3d ed. rev. Boston and New York: Houghton Mifflin Company, 1930.

[4] RADIUM IN GENERAL PRACTICE. By A. James Larkin, B.Sc., M.D. New York: Paul B. Hoeber, Inc., 1929.

The author's enthusiasm on the subject is quite evident in the work but it cannot be said that his claims are too extravagant. JAMES T. CASE.

IN the first half of the first volume of Stoeckel's *Handbuch der Gynaekologie*, Stoeckel has undertaken a recasting and rewriting of that old German standard work, Veit's *Handbuch der Gynaekologie*[1]. He has revamped the entire work but has retained the title, partially out of respect for Veit, his old teacher, and also because of the fact that the Veit *Handbuch* was for many years one of the better known German works. This work gives promise of being extensive as the first half of the first volume contains well over 700 pages. Stoeckel states specifically that in spite of the size of this work it is not to be a competitor of the even larger German work by Halban and Seitz *Biologie und Pathology des Weibes*, which has so recently appeared but rather to be a complementary work for the practicing specialist in gynecology.

The section on anatomy by Tandler is, as may well be expected, carefully written, profusely and well illustrated, and admirably set together. One criticism may be offered—that too much space is given over to a complete list of all references from the world literature. Of the 350 pages in the section of anatomy over 100 are used for an alphabetical listing of all references. This proportion holds throughout and it impresses the reader as a waste of space and material for this type of work. Such completeness is of no value to practicing gynecologists, the majority of whom have available one type or another of medical index. One interesting and comforting sidelight of this very complete bibliography is that at least in this German work cognizance is taken and due recognition is given to the American literature. This occurrence is so unusual as to deserve special comment.

The section on embryology by Spuler, of Erlangen, and the one on malformations by Menge and Getlinger, of Heidelberg, complete the first half of the first volume. They are written in much too simple a style, many facts are glossed over and apparently neglected and by contrast to the section on anatomy are inadequately illustrated. Future volumes must show improvement to rank this work with the really few standard works on gynecology in the world literature of today. RALPH A. REIS.

[1] HANDBUCH DER GYNAEKOLOGIE. Edited by W. Stoeckel. Vol. i, first half. Anatomie und topographische Anatomie Entwicklungsgeschichte und Bildungsfehler der weiblichen Genitalen. Munich: J. F. Bergmann, 1930.

CORRESPONDENCE

DR. THOMAS BOND—A CORRECTION

To the Editor: In the June, 1924, issue of SURGERY, GYNECOLOGY AND OBSTETRICS, you kindly published, over my name, a brief account of Dr. Thomas Bond, a Marylander by birth who rose to distinction in Philadelphia. Accompanying the article was a copy of the portrait obtained by me from the College of Physicians of Philadelphia and this picture appears in several publications[2] as the likeness of the Dr. Bond in whom I was interested.

Comparatively recently Miss Helen Cadwalader of Philadelphia, a descendent of Dr. Thomas Bond's brother, Dr. Phineas Bond, has investigated this picture and offers proof that it is a likeness of Dr. Thomas Bond of Watertown, Massachusetts who spent his later years in Philadelphia. There is, in the possession of Dr. William Pepper, of Philadelphia, a miniature said to be Dr. Thomas Bond, friend of Franklin and one of the founders of the Pennsylvania Hospital, of whom I wrote. An interesting article by Dr. Alison Scott in the *University of Pennsylvania Medical Bulletin* January, 1906, goes into this subject and has pictures of both the Drs. Bond in this article, and he is not entirely satisfied about the miniature. I note that in Morton's *History of the Pennsylvania Hospital*, there is no picture of Dr. Thomas Bond though there are pictures of practically all other doctors of importance in connection with this Hospital.

I deeply regret this error which cannot now be entirely corrected but with such authorities as those mentioned, the need for investigation or verification at the time I wrote my article did not present itself. If it had, the verification might have been obtained from one of the mistaken authors. WALTER D. WISE.

[2] A CYCLOPEDIA OF AMERICAN MEDICAL BIOGRAPHY by Howard Kelly, M.D., Saunders, 1912, vol. i, opposite page 96; The Sons of the University of Pennsylvania.